THE JULY
SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

THE SCIENCE PRESS

LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

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THE SCIENTIFIC MONTHLY

JULY, 1931

SIR JAMES HOPWOOD JEANS IN NEW YORK[1]

GREETINGS OF THE AMERICAN PHYSICAL SOCIETY

By Dr. W. F. G. SWANN

PRESIDENT OF THE AMERICAN PHYSICAL SOCIETY AND DIRECTOR OF THE BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE

MR. TOASTMASTER, it is my pleasant duty to convey to you, to Sir James Jeans, and to the guests here assembled, the most cordial greetings of the American Physical Society upon this very happy occasion.

There was a time, not very long ago, when, as a physicist, speaking to a group even of such profound mental caliber as I see before me, it would be necessary to explain what kind of beings I represented in my capacity as delegate of the American Physical Society. To the layman the word "physicist" betokened a kind of medical person, and probably a bogus one at that, who avoided prosecution for misrepresenting himself as a physician by calling himself "physicist."

Occasionally, when wandering through life trying to provide a reason for his existence, the physicist would encounter one of those nervous, haggard people of the type whose individuals are trying to "find" themselves, usually one of those very serious beings with a thirst for knowledge and the higher things of life. And she would say, "Ah, you are a scientist. I suppose you look at bugs under a microscope." And she would look at you in a manner which implied that she regarded you almost as a personal friend of the bugs. You hastened to tell her that you did not look at bugs under a microscope but devoted your activities to quite other pursuits. "Ah," she would say, "then you invent things. Do tell me of your inventions. What are you inventing now?" Then you had to say that you did not invent things—what you did was to seek the unknown, fathom the unfathomable, explain the inexplicable, and, as the darky preacher put it, "unscrew the inscrutable." You would say that your function was to expand the boundaries of knowledge—push back the horizon of discovery, and search for the hidden mysteries of nature for the benefit of

[1] Addresses at a dinner given in honor of Sir James Hopwood Jeans on May 28, by: The New York Museum of Science and Industry, The American Institute, The American Museum of Natural History, The Amateur Astronomers Association, The New York Academy of Sciences and The Scientific Monthly. Sir James's address was broadcast by the National Broadcasting Company.

the world and the good of mankind. And while you were saying all this, you became conscious of a look in her face amounting to a strong suspicion that you really didn't do anything at all which amounted to anything, and that you were just a great, big bluff trying to wiggle out of an embarrassing situation. Then, alas, as a physicist you envied the power vouchsafed to so many in other fields of learning—the power of oratory—the power to say nothing with force and conviction.

Now the engineer, such as our toastmaster, was in a much happier situation. Everybody knew what he did. Your impecunious solemnity contrasted poorly with his prosperous joviality. He simply bristled with prosperity; and, even in the pleasures of life, he did not seem to be limited to the one-half-of-one-per-cent. variety of iniquity which you enjoyed. If you doubted that he did anything, he could point to a locomotive and say, "See, I made that." He could point to a radio and say, "See, I did that." Of course, the poor physicist might plead that he had a small hand in the radio, too. "Oh, yes, poor fellow," one can imagine the engineer saying, "we do have a few of them in our employ."

This reminds me of a story. (Most after-dinner speakers are reminded of a story at the beginning, but some time or other you have to be reminded of it. It seems so much more natural to be reminded of it than to think it out beforehand, and so I am reminded of a story.)

Many years ago, when I was a youngster just through with college, I decided that I ought to know more about the practical things of science, so I went to take a course in electrical engineering. I felt that I wanted to learn really how big 1,000 amperes was. Of course, I could calculate things about 1,000 amperes, but I did not feel that I really had a personal acquaintance with it. I did not know whether I was justified in feeling that I was very noble and self-sacrificing in putting down the switch carrying it, or whether I should take out special insurance, or even say "good-bye" to my family.

So I took the course in electrical engineering. My partner in the laboratory was an old friend of my schoolboy days, an Irishman, wonderfully good-natured, but endowed with an uncontrollable desire to embarrass anybody who seemed susceptible to embarrassment. Some of the first work in that course concerned pure physics. Now I knew a lot about that, having just confounded all my examiners in their efforts to belittle and crush me in my praiseworthy ambition to secure the degree which I had just obtained. So I knew quite a lot of physics. As a matter of fact, I knew more physics than those junior instructors who looked after us in the engineering laboratory, and my friend, the Irishman, knew that, so he would come to me with all sorts of questions regarding the origin and significance of rather complicated and more or less empirical formulae which were used in the course. On the basis of the information thus gained he would proceed to seek out some of the junior instructors who had annoyed him in some way or other, and ask them very awkward questions about the formulae, much to their embarrassment and discomfiture. This, of course, did not increase our popularity in the laboratory. However, that was beside the point. One day we were assigned to work on a centrifugal pump. Now it so happened that in my work in physics I had had occasion to experiment upon very fine jets of water about a millimeter wide; but it was a terribly long stretch from these jets to the nozzle of that centrifugal pump. Never before had I seen such a "beast" at close range. I became very humble in its

presence. After checking up very carefully all the electrical connections and getting the Irishman to stand guard in case anything should happen, I hastily put down the switch and pulled it off again. The laboratory was still there, the universe went on its course, unconcerned, so I summoned up my courage, put the switch down again and left it down. The pump proceeded to roar and made an awful, angry noise, but it didn't deliver any water. Of course, I was horrified. I felt certain that we must have done something wrong and that we had probably "busted" the pump. Then, while we were meditating in sorrow, around came one of the junior instructors aforesaid. We bewailed our misfortune to him; his answer was, "But did you charge the pump?" Of course, we had not charged the pump. Whoever would have thought of subjecting the pump to such an indignity? However, he assured us that the pump would not mind, and pointed out a funny little opening, covered by a cap, near the top, where the water was supposed to be poured in. Well, of course, we felt rather foolish, so I decided we wouldn't make any mistake like that again. We would go slowly, step by step. We would start the motor first. Then we would slowly pour a little water into that opening at the top, and as the pump got gradually going, we would close that opening and let everything develop harmoniously. So I sent the Irishman up the ladder to the opening, (it seemed to me in every way appropriate that he should be the one to go up), and we proceeded according to our plan. Now no sooner did that pump taste the water that the Irishman poured down its throat than it set up a terrible furor, shot up a jet of water which drenched the Irishman and nearly knocked him off the ladder, and then proceeded to deliver from the business end a torrent of water such as I had never dreamed of. Well, of course, there was a great commotion and an awful mess on the floor—oil and water and everything. Then the head of the laboratory came around. I tried to look dignified, but it is very difficult to look dignified in the face of a mess of oil on the floor when you have been responsible for it. The head of the laboratory proceeded to "call us over the coals," but he stuttered very badly. (You know, I think it is one of the most embarrassing things in the world to be "called over the coals" by some one who stutters. You can not possibly help him out. It doesn't seem dignified to help him out, and you just have to stand still and wait until he has had his say, with the consciousness that the enforced periods of silence during his utterances also meant something very terrible, if only it could be expressed.)

Yes, even in those days, there was quite a difference between the materialism of the engineer and the asceticism of the pure physicist—the word "pure" not being intended to imply any moral turpitude on the part of other kinds of physicists—but to-day the physicist has delved into a realm of abstractness in which he views almost with a pitying tolerance the efforts of his predecessors to realize a concrete mechanistic structure. He sees them striving to invent a medium to pervade all space, a medium which could propagate light and heat and wireless waves—a medium in whose subtle properties it was hoped to find the explanation of gravitation and of everything else which needed an explanation in the universe. They would have liked to think of a medium such as water, but water would not do, because the kind of waves which water would transmit are quite unsuitable for light. An elastic solid would have been much better for light. But how could the earth and all the planets move freely through a solid? And so there was

much puzzling of brains to imagine how a medium could act on the one hand like the most limpid of fluids, and, on the other, like the most elastic of solids. The mathematical theory defined precisely the properties of the desired medium, the ether, but the mathematical equations looked cold and lifeless. There was nothing else in the universe which seemed anything like what this medium had to be; and, the grayer your hairs, the less you liked it. What was this mysterious medium? I believe it was Lord Salisbury who defined the ether as "a word designed to provide a nominative case for the verb 'to undulate.'" A little while ago, I gave another definition of the ether, a definition designed to call attention to the attitude of mind of one who spends too much energy in an endeavor to see a materialistic explanation of everything. And so I have ventured to define the ether as "a medium invented by man for the purpose of propagating his misconceptions from one place to another. Of all subtle fluids invented for the stimulation of the imagination it is the only one which has so far not been prohibited."

After all, the abstract point of view in science is not so bad when one gets accustomed to it, and particularly when one realizes that most of the things which catch the eye of the mind in pictures and theories most immediately palatable are often irrelevant to the purposes in hand. I have often meditated upon what I have called "the irrelevance of the obvious." I think of myself setting a problem to a little boy. The problem concerns a ball thrown upwards with a given velocity, and I ask him to calculate the time taken by the ball in reaching its highest point. He comes to me and complains that I have not given him enough information. I ask him what information he needs. He tells me he would like to know the color of the ball. I tell him that the color does not matter; but he may not like that, because a certain amount of the substantiality of the ball has vanished with its color. He asks for the weight of the ball, and I tell him that that doesn't matter, and I add to his troubles by telling him that I will withdraw even my remark that it was a ball, and leave its shape indefinite. Then, if he is over-materialistically minded, he will explode entirely and demand to know how he is to work out any problem about the body if I won't tell him its color, shape or mass. There is nothing left for him to think about, and he may well claim that it is difficult for the human mind to think at all unless it has something to think about. Well, to please him, I tell him the body is red, weighs ten pounds and is really a round ball. Now he is happy. He takes his paper and pencil, draws the round ball, puts a 10 inside it, paints it red in his mind's eye and works out the problem. When he brings me the result, I inquire at what point the redness of the ball came into his calculations. He looks through them and finds it didn't come in at all. The result would have been the same for a blue ball. Then I ask him where the 10 pounds came in. He looks again and finds he did not use it; or, if he did, it cancelled out, so that the result would have been the same for a fifty-pound ball. Finally, I ask him where the roundness came in, and he finds he did not use that at all. So I say to him, "Don't ask me for a lot of unnecessary things again." But I think I hear you sympathizing with the poor student. "What harm," you say, "did the redness of the ball do? Why did he sin in thinking it was ten pounds in weight and that it was round if, after all, these things did not matter?" Well, I agree that in this particular case the redness did no harm. But I suspect that if I let the student think the ball

is red he will come to me some day with some ideas founded purely upon the redness of the ball. He will be troubled, because he will want some other ball to do the same sort of thing that this ball did, and will be unable to satisfy himself because, perchance, the second ball is blue. Then I shall have to go to the trouble of raking up past history to show that the redness did not matter; but, if he has enjoyed the vision of redness for a long time, his whole mental equilibrium may be destroyed if I take it away.

An archdeacon has been defined as "one who performs archdeaconal functions." Sometimes we laugh at that definition; but, provided the functions are expressed explicitly, it is a very good definition—a much better definition, for example, than one which defines the individual in question as "one who wears gaiters and a top hat of rather ostentatious shape." It is true that the gaiters and the top hat are the most immediately obvious features of the archdeacon, but one who riveted his attention on these appendages as the most fundamental attributes of an archdeacon might be at a loss to understand the significance of the individual if for some reason he were without them, in spite of the fact that he might be just as good an archdeacon. The obvious part of the archdeacon is irrelevant to his true functions. So in science we encounter many instances where we choose to think of things mainly in terms of their activities, and we are loath to add to them appendages which may hinder or complicate those activities.

He who encumbers himself too much with the débris of irrelevant concepts is apt to build up for himself a confusion of troubles. He may have his ether with safety so long as he does not worry himself as to its boiling point or as to the question of whether or not it should freeze in the cold of interstellar space, and whether there should be icebergs of ether floating about. Analogy is all right so long as it is not distorted; for, in distorting it, we are like the dramatic person who, speaking of certain evils in his community, remarked: "The insidious influences are like a melting stream of warm water eating slowly but surely into the heart of an iceberg, burrowing on and on until they finally eat out the very center of gravity itself, causing the whole iceberg to turn turtle and dive to the bottom of the sea."

Physicists the world over recognize in our guest of honor not only a great astronomer, physicist and thinker, but one who has done much by his writings to guide the layman through those tortuous paths of modern thought to such realization as is possible to the nontechnical mind, of the modern point of view. To the layman he has acted as a catalyst of thought. For the benefit of those who do not know what a "catalyst" is, I must close by being reminded of a story:

There was an Arab who died, leaving all his worldly goods to be divided among his three sons—the first to receive one half, the second one a third, and the third one ninth. But his possessions were found to consist of seventeen camels. And when they came to make the division, they saw not how the seventeen camels could be divided, so they went in perplexity to the sheik. And the sheik, after deep thought, spoke thus: "My sons! Thy father was a great friend of mine, and though I am a poor man and have but one camel, for thy father's sake I will donate him to thy service that there may be no dissension among ye." So he added his own camel. And then he said to the first son, "Thy father gave thee one half of his worldly goods, but I give thee nine camels, half of eighteen, which is more than thy lot. Go thou

and be content." And he said to the second son, "Thy father gave thee one third of his goods, "but I give thee six camels—one third of eighteen—which is more than thy lot. Go thou and be content." And he said to the third son, "Thy father gave thee one ninth of his goods, but I give thee two camels, which is more than thy lot. Go thou also and be content." And then he counted up the camels he had allotted them, "nine and six are fifteen and two are seventeen," and there yet remained his own camel, which he took back once more, saying, "Lo, I have given each man more than his lot, and I get back my own camel. Blessed be Allah."—That eighteenth camel was a catalyst.

INTRODUCTORY REMARKS

By Dr. MICHAEL I. PUPIN

PROFESSOR OF ELECTRO-MECHANICS, COLUMBIA UNIVERSITY

Our guest of honor is an old friend of many of us. We learned to know him and to love him over twenty-five years ago when he was a young professor of mathematical physics at Princeton College. He was then a handsome English youth, and he is that still; successful intellectual efforts are obviously a wonderful preservative of physical beauty, especially when they result in four best sellers in four consecutive years.

I remember how glad we members of the American Physical Society were to see this quiet and unassuming Cambridge mathematician at our meetings, and how we missed him when his attendance began to show a rapid fading. Rumor had it that this shy Cambridge youth had suddenly grown sufficiently bold to court a bright and beautiful Connecticut lassie, that he had proposed, and that she had accepted him. The rumor proved to be true, and I said to myself: A Connecticut lassie knows a good thing when she sees it. The Connecticut lassie is Lady Jeans to-day.

That delightful romance of twenty-four years ago was the turning point in the brilliant career of our guest of honor. If it had not been for that romance he might still be a professor at Princeton College, pouring in daytime Newtonian philosophy into reluctant undergraduate heads, and wasting his precious evenings criticizing dull examination papers. But Jeans, the happy bridegroom, aimed higher than Jeans, the humble bachelor. He soon resigned his professorship at Princeton and returned to his old university where, during his Trinity College days, he had gathered many laurels in the fields of Newtonian philosophy. Soon after his return to Cambridge his American friends, including myself, were thrilled by the brilliant essay which he published in 1914. It was entitled "Radiation and the Quantum Theory." Several other essays of similar character followed in rapid succession, and they revealed what to his old American friends looked like a miracle. He, a most ardent disciple of the venerable Newtonian school of historic Cambridge, had become an inspired apostle of New Physics, first inaugurated by Planck and Einstein in the beginning of this century. This miracle reminded them of the miracle of St. Paul's sudden conversion on the road to Damascus. At that time Planck was an humble German professor, and he is that still; Einstein was a clerk in the patent office of Switzerland. New Physics, the great science of to-day, had humble beginnings.

Planck's Quantum Radiation and Einstein's Relativity Theory are the two foundation pillars of New Physics. Our

guest of honor believes that no one except a mathematician need ever hope to understand fully their endeavors to unravel the fundamental nature of the universe. Knowing that there are not many mathematicians in this distinguished gathering I shall not proceed any further in that direction. One application, however, of these endeavors makes the writings of our guest of honor so illuminating that I can not allow this occasion to pass without a brief reference to it.

According to New Physics radiation of heat and light by the luminous stars pours out the substance of these stars into the interstellar space. The mass of the stars diminishes and that of the interstellar space increases. Just as gravitation means concentration of cosmic substances into stellar centers, so radiation means their diffusion from these centers into the interstellar space. This mass diffusion by radiation, astronomy tells us, is millions of millions of years old. It has been kept alive, according to a brilliant suggestion of our guest of honor, by the transformation of atomic mass into radiation mass. He calls this process atomic annihilation, and traces its origin to the coalescence of the electrons and protons of the atoms in the stars as well as in the interstellar space, and to the transformation of the intrinsic energy of these atoms into the energy of photons, Planck's indivisible wave granules of radiant energy. The final result, which interests us human beings, is the flooding of the interstellar space with stellar torrents of photons of all possible wave-lengths, from the vanishingly short wave-lengths of the cosmic rays to the much longer wave-lengths of the rays which supply light and heat to our terrestrial globe. This picture, painted so well in the writings of our guest of honor, suggests to my mind the following thought which you will kindly permit me to mention here.

Each one of that practically infinite variety of photons seems destined to perform a definite service to the living world. Every blade of grass and every tiny flower on our meadows and pasture lands, every leaf of our forests and every gay flower of our honey-hearted gardens, can tell a wonderful story of that service. Nay, every microscopic and ultra-microscopic granule in the nuclei of our bodily cells will, perhaps, some day tell a secret tale of the service rendered by the cosmic rays to these tiny structures which are destined to provide a housing for the living soul of man. Whether those mighty streams of photons, speeding with the velocity of light from the countless billions of the blazing stars into the interstellar space, are hastening to perform some other useful service in some other hidden corner of the universe science can not tell. Science can not penetrate the mysterious veil which covers the face of the space-time entity, separating the world of ultimate reality from the world presented to our senses and interpreted by mere pictures of mathematical symbols. Faith alone penetrates it and finds behind it the throne of the divinity which created that space-time entity and filled it with electrons and protons, and with their offspring, the omnipresent photons, the tiniest and liveliest energy granules in the ever-expanding interstellar space. One can not resist the hope that some day, perhaps, we might discover that these ultra-refined energy granules are responsible for the first beginning of life and for its never-ending evolution.

These are some of the thoughts suggested to my mind by the brilliant writings of our guest of honor, Sir James Hopwood Jeans.

MODERN THEORIES OF THE UNIVERSE

By Sir JAMES HOPWOOD JEANS, KT., D.Sc., LL.D., F.R.S.

DORKING, ENGLAND

OWING to a happy inspiration on the part of those who arranged the dinner I am not called on to make an ordinary after-dinner speech of the conventional type. I have been asked to speak about the advance of science in the last few years. At the same time, I am sure I shall not be doing wrong if I take one or two minutes of my time to thank the toastmaster, my old friend, Dr. Pupin, for his very kind and very generous introduction, and to thank Dr. Swann for his message from the Physical Society; and to thank you all for the very cordial reception which you have given me and which has touched me so deeply.

It was, I think, inevitable, when I was asked to choose a subject to-night that I should think at once of the contrast between the science of to-day and that of twenty-five years ago, when I was here teaching in your country. Let me, however, turn my thoughts and your thoughts back a little bit further than that. Let us go something like fifty years back into the age of mid-Victorian materialism. We find that science did not then contemplate the universe at all. Science could be compared then to a series of roads which diverged out in different directions—physics in one direction, chemistry in another, astronomy in a third and so on. All these roads radiated out from a center, which was, in brief, our noble selves.

We took mankind, so to speak, to be the center from which science worked. Astronomy moved out a certain distance —a very small distance as we now know—from our home in space and explored the near neighborhood of our own little planet. Physics tried to discover what it could about Nature and matter, but it was never able to get down to the small ultimate fabric of the universe. The particles of which matter was built were too small for examination in those days. We could only examine particles which were of such a size as could be seen by our human eyes or by optical aids fashioned by human hands. And so it was all along the line.

As a result of that it was inevitable that we should think of the universe as being something like the material tool, so to speak, with which we examined it. In the ordinary events of everyday life such as were then studied, we found that bodies moved as they were pushed or pulled. The simplest physical experiment was one performed with our muscles—let us say, lifting a weight. We found that all the objects around us acted as though they were pushed or pulled by force similar to those of our muscles. And the physicist of those days created for himself a universe in which he imagined that however far one went along any one of these roads, he found bodies, substances, which acted simply in accordance with the pushes and pulls which were exerted on them. He thought, in other words, of the universe as a purely mechanical structure.

Then came ten wonderful years, five years at the end of the last century, and five years at the beginning of this—the years 1896 to 1905. When the history of science comes to be written in its proper perspective by one remote descendant, it will, I think, be found that those ten years rank at least as high as any ten years in the past history of science. The discoveries of those ten years will stand at least as high as the discoveries of the ten wonderful years starting with 1609, when Galileo first explained to men how to work the telescope, and so discovered a new structure of the heavens. They will stand as high,

I think, as the discoveries of those wonderful years which began with Newton's work while he was still an undergraduate at my own college of Trinity College, Cambridge, and ended by his announcing the law of gravitation and proving that the universe was subject to universal laws.

To the ordinary man, I suppose, those ten years are generally regarded as the ten years in which physics became unintelligible. The picture that he had drawn for himself of the universe around us became replaced by what Dr. Swann has described as the heartless and cold-blooded formulae of mathematics. But to scientists, those ten years meant very much more than that. To the scientist, and to a lesser degree the ordinary man, they represent the epoch in which science assumed a new aspect of thrilling interest, in which we first began to contemplate the universe as a whole, and in which instead of thinking of science as a few roads diverging out from our own circle, we rather began to think of it as a whole lot of roads converging on one central point and leading to an understanding of the universe as a whole.

Let me remind you of the tremendous discoveries of those ten years, discoveries of which we haven't yet seen the full implications.

The first two or three of those years saw the electron isolated, and resulted in our discovering that it had a definite structure. We began to think of it almost as a universe in itself and no longer as a sort of hard particle which had been left to us from the times of Democritus and Lucretius. In those same years radio-activity was discovered, and that perhaps more than anything else has helped us unravel the mysteries of the atom and the innermost structure of the material of which the universe is built.

Then with the turn of the century in 1900, the quantum theory was introduced by the genius of Professor Planck, of Berlin. We still haven't seen the full implications of that either, but it has, at least for the time, abolished determinism from physics. No one can say whether it will be restored or not; but at least it has put before us a picture of a universe which is governed by something entirely different from the hard-and-fast mechanical laws which our Victorian ancestors imagined.

Then—at the end of the ten years—came Einstein with his theory of relativity. This took away the material basis on which we had worked for so long, and through that more than anything else, perhaps, the study of physics became unintelligible to the ordinary man, and of thrilling interest to the scientist—as also to the philosopher.

Throughout those ten years another phenomenon was emerging, cosmic radiation, of which we haven't yet got to the bottom. These cosmic rays come to us as messengers from the first depths of space, and their message, as far as we can read it, seems to be that the physics and chemistry that we study on earth are only tiny fringes of enormously vaster subjects. The physics and chemistry of space seem to be something wider and bigger than anything we have yet imagined, and these cosmic rays come to us to tell us of conditions prevailing in outer space.

All those subjects which I have touched on have their foundations in research which was carried on by hard-working scientists in that single decade that I have mentioned. Only now we are beginning to suspect the full implications of those discoveries. And yet, little though we know, I think it is fair to say that by now science has in a sense surveyed the universe from one end to the other, from the largest objects known in it, the great spiral nebulae, down to the smallest objects, electrons and protons. We believe there is nothing larger than the spiral nebulae, except the whole

universe itself, and, as far as we know, there is nothing smaller than the electron which has a permanent existence as a physical structure.

And now whichever way we look at the universe, an extraordinary phenomenon emerges. We find we can no longer interpret the universe, either in its smallest or its greatest aspects, as a sort of mechanical phenomenon, in the way in which our mid-Victorian ancestors would have interpreted it. We look at one end, the thing smallest we know, the electron, and we find that this must be regarded not merely as a hard particle, or merely as a charge of electricity, but rather as what the physicists describe as a wave packet. If we want to compare it to something, we must not compare it to a material object, but rather to something of the nature of a storm at sea, a collection of waves which move in certain ways and by the way they move determine the whole phenomena of gross matter. The materialist at once asks: "Waves in what?" And the answer we have to give is—waves in nothing at all, because there is nothing left in science in which waves can undulate, to use Professor Swann's term. The ether being abolished by the theory of relativity, everything we know with any capacity for undulation has disappeared, and the waves must be regarded purely as mathematical waves. They are, so to speak, descriptive rather than a material phenomenon. We can express those waves by mathematical equations, but if we try to go beyond that and express them as waves of something material, we are at once led into a tangle of absurdities and contradictions.

It is much the same with electricity itself. We must now think of electricity simply in terms, I believe, of mathematical formulae. Last Sunday I read in *The New York Times* a verbatim translation of Professor Einstein's lecture. As might be expected, he did the best that any man could do to explain the nature of electricity, or his present views on it; and yet, as I read it, I wondered to how many readers what he said would be at all comprehensible. It is probably safe to say that no one who is not a trained mathematician could take very much out of that lecture. They couldn't, at least, follow Professor Einstein's thought in the way in which it deserved to be followed.

We used to think of all natural phenomena as a result of forces. Einstein has abolished force from Nature. We no longer believe there is any such thing as force. Particles and larger objects simply follow paths, which are determined by something different than force. They are determined by the curvature of space, and when we try to inquire what this curvature of space means, no one except a mathematician can really answer the question; and when a mathematician does answer it, no one except another mathematician can understand it.

When we look at the other end of the universe, with our astronomy of the last few years we have discovered that space is something enormously greater than we ever thought it to be. We used to in the past think of space as the solar system and a little bit outside it. We know now that the solar system is about as one grain of sand in the universe compared with all the sand on all the seashores in the world.

It is the same with time. We used to think of time as extending through the whole of human history and perhaps a little bit beyond. We now think of time as something so immense that all human history is only the twinkling of an eye. We can take a postage stamp and represent by the thickness on that postage stamp the whole of recorded human history. We can stick that postage stamp on the top of the Chrysler Building, and the Chrysler Building will not be high enough to represent the rest of astronomical time.

And yet, the most surprising discovery has not been that space and time is so vast. It has rather been that they are finite, and limited in all directions. We can't go on through space forever. If we do, we just come back. We can't go on through time forever. If we go in one direction, we come to something which is called the beginning, although we don't know what that means; and if we go in the other direction, we probably come to something which may be called an end, although we don't know what that means.

And again, the average man who is not a mathematician can't properly realize or visualize what we mean by finite space or by finite time. They come out nicely in a mathematical formula, but as soon as you try to draw a picture of either, you are done for. They are not things which permit of material representation in any form whatever.

Any one who has lectured on these subjects or written on them is accustomed to getting letters by the basketful telling them that they are talking nonsense. People say space can't be finite because outside it can't be anything but more space. If you say space is finite, your correspondents tell you it simply shows you don't know what you are talking about. Well, the answer, of course, is that all these good people are trying to make material representations of space and that space does not permit of this. As soon as one thinks of space as a mathematical concept, or even as a mere concept without mathematics, finite space becomes intelligible. It is like the finite space of one's thoughts. One can think of New York without thinking of the whole of the United States, and one can speak of the space in New York without being told it is an absurdity, because there must be space outside.

Then space as a thought, as a mental concept, is intelligible and satisfying, and from that concept in the way in which it is treated by Einstein, all these phenomena—gravitation, electrical forces, etc.—seem capable of emerging. But if once we try to picture space as something concrete or material, we simply can't answer the objections of these people who write and say it is absurd to talk about finite space because there must be more space outside.

The same difficulty comes up in a more acute form in respect of a newly discovered phenomenon—the expansion of the universe. These great nebulae now appear to be receding from us with terrific speeds in all directions. The simplest explanation, and one which has mathematical support, is that space is not only finite, but is continually expanding. Space itself is getting larger and larger. The person who tries to make a concrete picture of this, of course, objects at once that space can't get larger and larger if there is nothing but space to expand and eat up as it increases except more space. So long as we think in concrete terms, that argument is pretty well unanswerable. The answer to it is that we must not think of space in those concrete terms. We must think of space as a mathematical concept as a mental concept, such as the mathematician is familiar with, and such as he handles every day.

It is the same throughout the whole of astronomy with the universe as a whole. It is the same throughout those parts of physics which deal with the smallest particles of matter. None of the concepts which we come upon can be pictured in material terms. Always we come to concepts which mathematics and its symbolism can explain admirably, but which the concepts and the terminology of the engineer fail completely to explain. If we think of the universe in terms of mathematics, in terms of pure thought, or in terms of mental concepts, it becomes comprehensible. If we think of it as a piece of machinery, as we used

to, an ocean of machinery spread out around us in the ether, extending in all directions and acting by its pushes and pulls, it not only becomes incomprehensible, but when we try to discuss it or argue about it, it leads us into an absolute morass of contradictions and inconsistencies.

Such in brief, as it appears to me, is the change which has come over physics in the last few years, even in the time in which we ourselves have been working in physics. The philosophical implications are, of course, tremendous. They remain to be worked out, and it will be a long time, I think, before the last word has been said. What I wish to suggest to you and try to picture to you in the few minutes which have been at my disposal has been the tremendous change which has come over our most fundamental and innermost ideas as to the structure of the universe. We must no longer think of it as a great, elaborate piece of machinery crushing us by its weight, but rather as a universe of thought, which can only be understood if we approach it by thought, and in particular, by that particular kind of thought which we describe as mathematical.

THE DEVELOPMENT OF THE EGG AS SEEN BY THE PHYSIOLOGIST[1]

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In the preceding lecture[2] our attention was called to the intrinsic or innate potentialities of the fertilized ovum as it starts out on its career for better or for worse. Its capacity to grow is determined when the egg or maternal gamete and the sperm or paternal gamete fuse. While the new individual has inherited limitations by virtue of which an oyster egg, for example, need not aspire to be a fish, nor one of my monkey eggs a man, it yet devolves upon the maternal parent, from the lowest species to the highest, to place the egg in the environment best calculated to favor the development of the offspring. Thus, butterflies lay their eggs upon the favorite species of plant. Fishes and Amphibia exhibit elaborate behavior patterns for mating and for the care and protection of their offspring; indeed, the more one studies these lowly vertebrates the more respect one has for the denizens of the waters in comparison with the much adored birds, denizens of the air. That birds are more marveled at in the variety of their reproductive instincts—migration, courtship, song, nest-building—while fish are just "poor fish," is just another example of beauty passing for brains. For fish too have courting colors of brilliant hues, build nests and defend them and their eggs and young with great courage—complex activities, all under the stimulus of internal physiological processes that have to do with reproduction, in the possession of which birds do not surpass fish, and both, in some respects, equal the mammals.

These examples are cited to show that the whole chain of endocrine glands that we know in mammals and man are already functional in the lower vertebrates. Indeed, in all classes of backboned animals except the birds there occurs here and there the intra-uterine form of gestation, sometimes, though erroneously, considered a mammalian character. When Joan Lowell writes in her notorious "Cradle of the Deep" that she "learned about women from the shark" she indicated a biological truism, for sharks do have as complete and intimate a union of mother and fetus as exists, for example, between the unborn calf and its mother. We may, indeed, generalize to the extent of saying that there is nothing about the reproductive process in man and mammals that is not foreshadowed in the so-called lower classes mentioned. One may in fact affirm with confidence that fundamental discoveries in the field of reproduction, even as applied to the human species, will be made by studying the lower forms: the salamander, the pigeon, the lowly guinea-pig. In this lecture, however, especially since we are working on mammals, particularly monkeys, which after all come closer to man, we shall speak about the mammalian egg, and trace its behavior from conception to birth.

From the title one might suppose that the intrinsic physical and chemical factors of development were to be discussed. But of internal protoplasmic drives, adjustments, regulators, we know only from the study of amphibian and invertebrate eggs. Instead, the present lec-

[1] From a symposium on development given at the Carnegie Institution of Washington in November, 1930.

[2] Dr. George L. Streeter, "The Development of the Egg as seen by the Embryologist," Sci. Mo., June, 1931.

ture is a kind of prosaic "Aeneid" that relates, in an un-literary way, the origin, the wanderings, the dangers and vicissitudes that beset the microscopic hero, not on unfriendly shores and the Stygian darkness of the hereafter, but in the once mysterious darkness of the ovary, the oviduct and the womb. The hormones as guardian angels preparing the way and guarding the temporary domiciles will loom large in the story. The egg will be traced as a microscopic traveler from its beginnings, where it is more or less passive, through its development, where it later makes itself felt and is the center of far-reaching interactions with the mother harboring it for so long a time. For pregnancy involves profound changes in the female organism which are only beginning to be understood. The egg, by which is understood also the embryo or fetus with its envelopes and placenta, forms the center from which emanate stimuli that initiate changes calculated to maintain the life of the new individual in the making. The nervous element steps into the background, the glands of internal secretion come to the fore.

Of the glands sketched in black in Fig. 1, the ovaries and the hypophysis, more particularly the anterior lobe, are of prime importance. The thyroid and the hypophysis are intimately linked in mutual association, for when one is interfered with the other languishes. Pineal and thymus have to do with sexual maturity and the cortex of the adrenals has some relation, poorly understood, with its twin in embryonic development, the ovary or the testis. The parathyroid has to do with calcium metabolism and so does the ovary. With the changing metabolism of pregnancy the pancreas and the liver become involved. On the whole, however, for the present purpose we may dismiss from consideration, as having no very specific effect on the fate of the fertilized egg, all the endocrine glands except the

FIG. 1. OUTLINE OF FEMALE MONKEY WITH SOME OF THE ENDOCRINE GLANDS DRAWN IN BLACK. THE ARROWS INDICATE THE RECIPROCAL RELATIONSHIPS AMONG THE GLANDS, AND THE ORGANS MORE DIRECTLY AFFECTED BY THEM.

ovaries and the anterior lobe of the hypophysis. Even the posterior lobe of the latter, source of the far-famed and much-abused pituitrin, artificial birth initiator, has probably nothing to do with spontaneous normal birth at term. Uterus, placenta and embryo may possibly also function in an incretory way during pregnancy.

In this brief hour, therefore, we shall follow the fortunes of the egg as this reacts with the ovaries and the anterior lobe and we shall consider the revolution which the egg in its turn stirs up while it reigns as the *primum movens*, during its sojourn within the mother's body. In this way we may lay more emphasis upon the anterior lobe than this deserves, because the ideas are new and now have a vogue. But certainly the newer ideas are based upon more experimental evidence than the ancient theory that the gland is the seat of the soul! We do

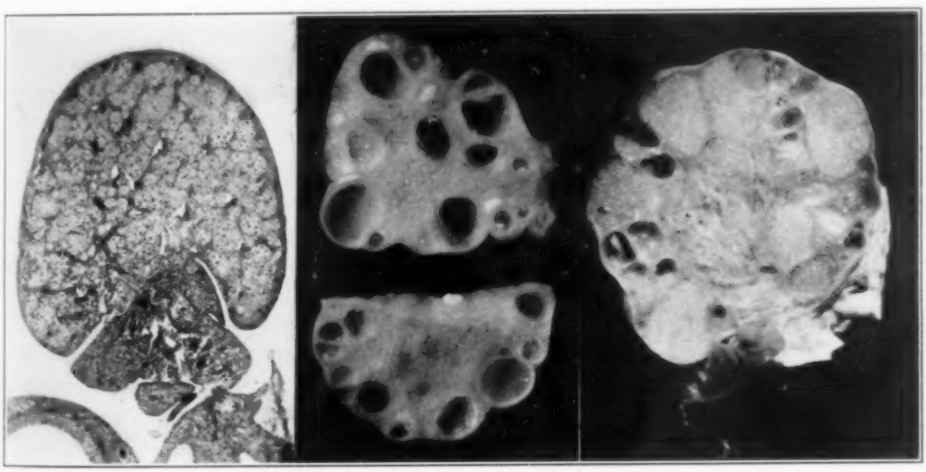
know definitely that it is the mighty regulator of the reproductive organs.

Since the dictum *omne vivum ex ovo* is as true to-day as a hundred years ago, let us begin by considering the origin of the eggs. As the ovary develops in the female fetus *in utero*, showers of eggs (Fig. 2) multiplying by successive divisions, grow down from the surface of the ovary and invade the depths of the organ, to arrange themselves later as independent structures, wrapped in a single sheet of the thinnest nurse cells. At birth a girl possesses 100,000 to 500,000 such eggs in her ovaries. Of these she needs at best one every moon or not over 500 from 13 to 53 years of age; hence the vast majority are doomed to destruction without even being shed. This degeneration and resorption goes on from birth to the menopause and constitutes a continuous bombardment of the female organism with hormones. The resorbed substances may be the ones that make the female what she is according to the dictum: *mulier est quod ovarium est*—a woman is what her ovaries make her.

The prodigality of nature as to the production of eggs in mammals is even greater than just stated according to those who hold, with some reason, that throughout the reproductive period of life the production of new eggs proceeds without interruption and *ad infinitum*. In spawning fish there is no greater chance for operation of the law of survival of the fittest than in the mammalian ovary.

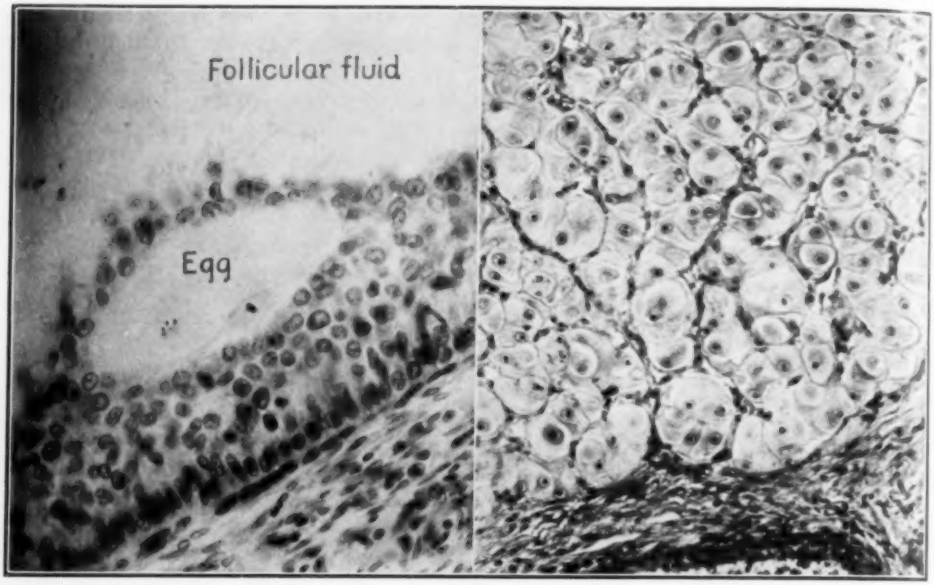
At puberty a change takes place, not suddenly but nevertheless profoundly. The ovarian follicles grow larger, the internal secretion of the ovaries more intense. It now appears that in these changes the direct factor is the anterior lobe, for it is possible, by injection of extracts or transplantation of the gland substance itself, to bring a baby mouse or a baby monkey to "maturity" in a few days' time. The ovary is directly affected by the anterior lobe hormone and responds by the swelling of one or more follicles, usually only one in man and monkey, in the manner now to be detailed and illustrated.

Let us, then, visualize the growth of



FIGS. 2 TO 4. OPOSSUM OVARIES

FIG. 2. MICROSCOPIC SECTION THROUGH THE OVARY OF A POUCH YOUNG 23 DAYS OLD. THE ORGAN IS SOLIDLY FILLED WITH EGGS. FIG. 3. TWO HALVES OF OVARIES CUT IN TWO TO SHOW IN EACH SEVERAL LARGE FLUID-FILLED GRAAFIAN FOLLICLES. FIG. 4. OVARY CUT IN HALF TO SHOW THE SOLID CORPORA LUTEA. THE KNIFE PASSED THROUGH FIVE CORPORA.



FIGS. 5 AND 6. FROM SECTIONS OF OPOSSUM OVARIES, GREATLY MAGNIFIED

FIG. 5. MARGIN OF A GRAAFIAN FOLLICLE, SHOWING RIPE EGG WITH POLAR BODY AT LOWER RIGHT AND CHROMOSOMES WITHIN THE EGG. FIG. 6. MARGIN OF CORPUS LUTEUM, THE LARGE CELLS OF WHICH ARE THE METAMORPHOSED NURSE CELLS SHOWN IN FIG. 5.

a Graafian follicle by examining a number of stages. The egg at first is structurally the center but always remains the physiological center, for without egg no growing follicle. The egg itself increases during its period of growth ten times in diameter, a thousand or more times in volume, while its nurse cells multiply until many layers deep. By this time the growth of the egg is nearly complete, but this is not yet "mature." A vascular tunic surrounds the whole, for now more nourishment is needed.

The next step is the secretion of the liquor folliculi which begins to accumulate among the cells, pressing them farther and farther apart in large fluid-filled spaces which coalesce into a great space or antrum (Fig. 3). Finally the follicle is like a clear, bladder-like cyst that bulges from the ovary by virtue of its shape and size. The egg occupies a little hillock of nurse cells somewhere—anywhere—on the follicle wall. All this secretion probably goes on under the direct stimulus of the anterior lobe (Fig. 1).

Now what has all this secretion to do with the egg? The function of the liquor folliculi is twofold: it affords a medium for carrying out the egg at flood tide, as it were, when the follicle bursts; and second, it constitutes an internal secretion which is absorbed by the mother for the further preparation of her body for the care of the egg.

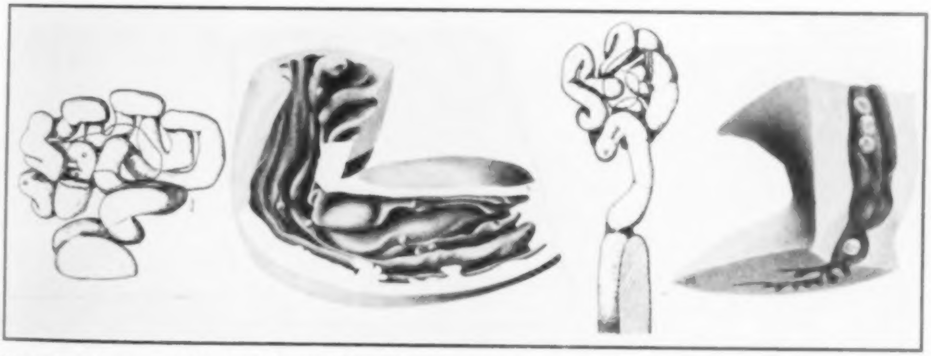
The hormone of the follicle has several functions, partly identified by names applied to it: (1) *Folliculin*, because formed by a Graafian follicle. We now know, however, that it can be secreted by x-rayed ovaries devoid of follicles, and it is found in the placenta in large amounts, and may possibly even be made there. (2) *Oestrin* is a more expressive term, for the test of its presence is oestrus or "heat" produced in spayed mice or rats. (3) We might finally call it the *female sex hormone*, responsible, among other things, for the secondary

sex characters of the female. (4) It now appears that an important function of this outpouring of liquor folliculi is the *stimulation of the anterior lobe*, in preparation for the next step, the formation of corpora lutea, as we shall see presently.

Let us return to the large follicle of the monkey ovary. Among the many unanswered questions that arise at every step of our story is this: Of the thousands of primordial follicles that lie dormant in the monkey ovary, why should a certain one be singled out and suddenly begin to grow and swell like a mushroom? This phenomenon speaks for a beautifully controlled mechanism. The anterior lobe is the prime mover in this process, but so far attempts to imitate nature with transplants of the gland or extracts have resulted only in a wild growth of many follicles. What the controller is that normally puts on the brakes at the proper time and place we do not yet know. It has been suggested that the inhibitor is the follicular hormone of the one follicle that gets the head start, as indicated by the arrow in Fig. 1.

In our story we have now arrived at the point where the mature egg in the mature follicle is ready to be liberated. Such an egg has one half the chromosomes of the species (24 in the rhesus monkey as in man). One half of the chromosomes have been discarded and are to be found in the polar body. Fig. 5 shows such a polar body and some of the chromosomes of the ovum. Such an egg is ready, as soon as discharged, to meet the sperm or male sex cell in the process of fertilization, as will be fully elucidated in the succeeding lecture of this series. Fusion of the gametes, female and male nuclei, takes place in the upper reaches of the oviduct in the monkey, as probably in all mammals including man.

In the bursting of the follicle to liberate the egg we are confronted by the enigma of its physiological causation. Most mammals, including man and monkey, ovulate spontaneously, that is, in the absence of the male. The rabbit, the ferret and the cat are different; in these mating is necessary for ovulation. In the rabbit, almost precisely ten hours after mating the eggs are discharged from the ovary. If we couple this fact with the finding that the female rabbit can be made to ovulate by the injection of anterior lobe hormone, we may suppose that normally nervous excitation stimulates this gland, so close to the



FIGS. 7 AND 8. SKETCHES FROM ENLARGED WAX MODELS OF THE OVIDUCT OF THE RAT (FROM HUBER)

IN 7A AND 8A. THE TRANSIENT EGGS ARE INDICATED BY TINY RINGS; IN 8A FOUR EGGS HAVE NEARLY REACHED THE UTERUS. FIGS. 7B AND 8B. DETAILS OF THE PORTIONS OF THE TUBES CONTAINING THE EGGS.

brain, to put out an "ovulatory" hormone.

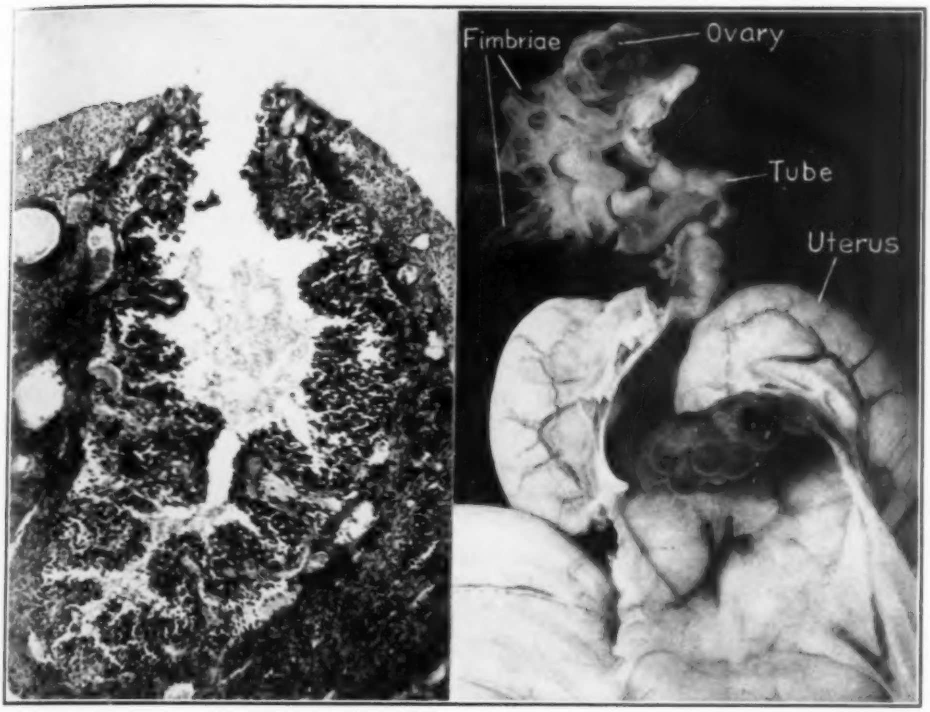
Ovulation, then, is a most momentous act, the *sine qua non* of reproduction. It marks the culmination of long preparatory processes. A four-year-old monkey, just mature when ovulating for the first time, has been engaged for four and one half years in preparation for the act, for we must include the prenatal as well as the postnatal development.

The wandering of the egg (Figs. 7 and 8) now fertilized, to its "nesting" place or implantation site offers interesting and unsolved problems. The egg, discharged upon the ovarian surface and literally deposited into the body cavity, finds its way into the tiny lumen of the oviduct through the mediumship of the fimbriated opening or "funnel" leading into it. This consists of folds like far-flung neck ruffles—soft expansible flaps that are highly mobile, especially at ovulation time (Fig. 10). The funnel edges envelop the ovary-like broad bands and are, moreover, covered with cilia that waft a stream of peritoneal fluid into the tube which thus carries the egg with it. The motility of the funnel and even the very presence of cilia depend upon ovarian hormones elaborated concomitantly with the development of the egg and exerting their influence just at the right time. Whether ciliary action is entirely responsible or is even important in the transfer of the egg down the tube to the uterus is not yet settled. The alternative theory that the contractions of the muscular wall of the tube are largely or entirely responsible seems very reasonable. The passage of a bolus of food down the intestine offers a parallel. It is certain that just about ovulation time the tube is very active but the spontaneous motility gradually subsides. More remarkable than the mere passage of the egg is the fact that it requires so long as it does, namely, three days, for most mammals, large or small, for example, cow or mouse. In other words, the passage into the uterus is delayed, doubtless to give that organ time to prepare for its reception. This slow passage is probably associated with the sluggishness of the tube which is brought about by the successor of the ruptured ovarian follicle, the corpus luteum.

A problem analogous to the transport of the fertilized egg *down* the oviduct is the transport of the independently motile male sex cells, the spermatozoa, *up* the genital tract. Is it by its own efforts, by the lashing of its vibratile tails, that the spermatozoon reaches its mate? Is it by a stream of upward-beating cilia as in birds and reptiles? Or is it by the never-ceasing muscular contraction of the maternal organs, that the fathering elements are carried passively and resistlessly along? Facts are accumulating to show that the last theory is the most likely one, a conclusion which would explain the high degree of motility of uterus and oviduct during the "heat" period when the supply of folliculin is at its height.

In the last few paragraphs the reader has been reminded of further purposive events transpiring in the prospective mother's body—changes in the endocrines, responses by the mother's organs, calculated to nurture and transport the precious egg—not too fast, not too slowly, so that events may synchronize and processes harmonize. How much influence the free egg itself exerts is problematical, but probably none so early in its history.

Let us leave the egg, three days older but not a whit larger, resting for a time in the lower end of the oviduct ready at the next signal to enter the more cavernous uterus, and let us return to the collapsed follicle that has given up the egg it had nurtured to maturity. It is like a building after an earthquake.

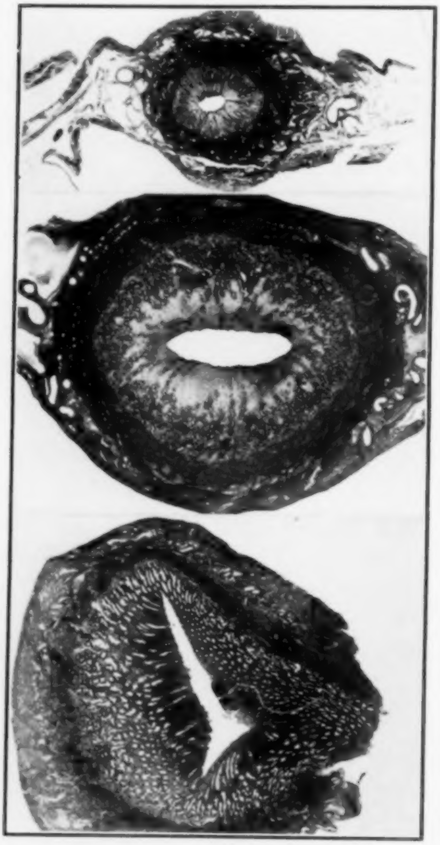


FIGS. 9 AND 10. SECTION OF COLLAPSED, FRESHLY RUPTURED FOLLICLE, SHOWING POINT OF RUPTURE THROUGH WHICH THE EGG HAS ESCAPED. FIG. 10. DISSECTED OVIDUCT OF THE OPOSSUM, SHOWING LOOSE FIMBRIAE THAT EMBRACE THE OVARY TO CATCH THE EGG; PHOTOGRAPHED FRESH IN WATER.

All is chaos at first—blood, nurse-cells, capillaries and connective tissue all topsy-turvy (Fig. 9). But from the wreckage, phenix-like, arises a new structure. The nurse-cells metamorphose in a marvelous fashion. Some of them may multiply, but all of them swell to twenty or more times their original volume. Eventually their aggregate volume stops the gap and more, for the new gland, now an almost solid structure, may exceed the mature follicle in volume (Fig. 4). The nurse-cells soon contain fine fat granules and "lutein," which imparts a yellow color to the structure and has given rise to the name corpus luteum or yellow body. This luteinizing change is probably under the control of the anterior lobe, whipped into this new action by the liquor folliculi spilt at ovulation and resorbed by the blood. The corpus luteum is a typical gland of internal secretion. Blood vessels have grown in among the cells so that there are none but what lie contiguous to capillaries. Here the blood takes up from the cells and carries to the uterus the chemical messengers needed for the further development of the egg. The very structure suggests a gland (Fig. 6). That it is a gland is conceded, but its functions have been the center of controversy for thirty years and the end is not yet. If we will summarize some of the alleged functions of the corpus luteum we shall at the same time learn something of the needs of the developing egg.

(1) Before the advent of the egg in the uterus and its attachment there, the

corpus luteum prepares the lining of the uterus to make it a fit nesting place. The membrane becomes swollen, fluffy, well supplied with blood, secreting "uterine milk," so called, for the nutrition of the egg. Figs. 11 to 13 show stages in the growth of the monkey uterus, the last marking the condition of early attachment. Corpus luteum extract injected into rabbits or monkeys will bring this necessary "pregravid"



FIGS. 11 TO 13. SECTIONS THROUGH THE ADULT MONKEY UTERUS

FIG. 11. THE "RESTING" STAGE, NOT YET WHIPPED INTO ACTION BY THE ENDOCRINES. FIG. 12. THE PREMENSTRUAL ORGAN ACTED UPON FOR SOME DAYS BY THE CORPUS LUTEUM. FIG. 13. UTERUS WITH A 19-DAY OLD EGG IMPLANTED (DARK SPOT). THE GLANDS HAVE DEVELOPED CONSIDERABLY UNDER THE 19-DAY INFLUENCE OF THE CORPUS LUTEUM.

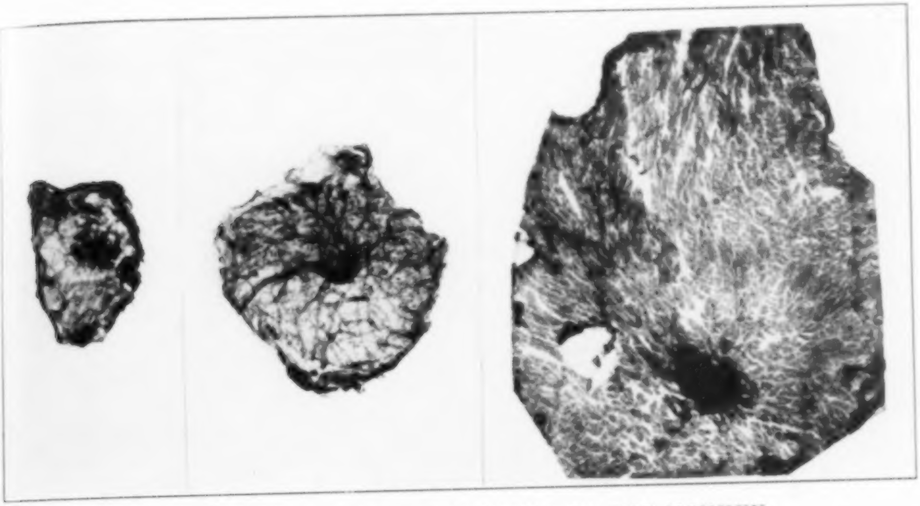
condition about, probably directly, although here again the anterior lobe may play a part, acting under the stimulus of the corpus luteum as it previously acted under the stimulus of the follicular hormone (Fig. 17).

(2) The pregravid preparation just referred to takes place in the monkey and in women during each monthly cycle; but if the egg is present and attaches itself certain connective tissue cells about the egg swell until they look like typical gland cells. Decidual cells they are then called, that form the decidua, whose function we shall note presently. Now, the corpus luteum has been found to sensitize the connective tissue cells of the uterus, so that, on irritation, this metamorphosis of small slender cells into large rounded ones takes place. But the anterior lobe extract will do the same; perhaps the corpus luteum actually performs the function via the anterior lobe—another doubt that faces us in these complex relations.

(3) Since it is obviously needless during pregnancy for more eggs to mature or more follicles to grow, this function is for the time suppressed. Until recently the corpus luteum was supposed to perform this function of suppression. But other factors, little understood, are known to be effective in this direction, for instance, lactation.

(4) Once begun, the pregnancy is continued under the ægis of the corpus luteum, at least in the early stages, for castration leads to the death of the embryo. The guardian angel, the corpus luteum, may not act on the embryo directly, but probably serves this guest by providing an active blood stream to be maintained through the organ.

(5) The corpus luteum has been supposed to prepare the mother for birth by relaxing the birth canal, loosing the ligaments of the pelvic bones, modifying liver, kidney and other organs. But it is more probable that it is the ante-



FIGS. 14 TO 16. MAMMARY GLANDS OF THE MONKEY,
TRIMMED FROM THE SKIN AND SPREAD. FIG. 14. THE DARK AREA IN THE MIDDLE IS THE POORLY DEVELOPED MAMMARY TREE OF AN IMMATURE FEMALE. FIG. 15. ADULT, "RESTING" STAGE. FIG. 16. LATE IN PREGNANCY.

rior lobe that does this, acting under the stimulus of the egg, embryo or fetus, which brings about these profound changes.

(6) When the baby is born the breasts must be ready to nourish it. The preparation for lactation requires the entire period of pregnancy and consists in growth of the "mammary tree," the secretory alveoli and the milk ducts. Figs. 14 to 16, monkey breasts removed from the skin, illustrate the point. This growth has been attributed to the corpus luteum but has now been shown also to be an anterior lobe effect. The experimental results are in keeping with the observation that the mothers whose ovaries are removed during pregnancy may still suckle their young.

We thus see that from somewhere emanate hormones that transform the pregnant mother in a most marvelous fashion (Fig. 17); but these hormones are elaborated only under the whip of the egg that constantly sends out orders, as it were, that its needs may be met. The mother responds to the limit of her vitality. If she has weak organs, the added demands of gestation will find them out. The corpus luteum had at one time the chief honor of "train dispatcher," but the anterior lobe is now thought to dominate the reproduc-

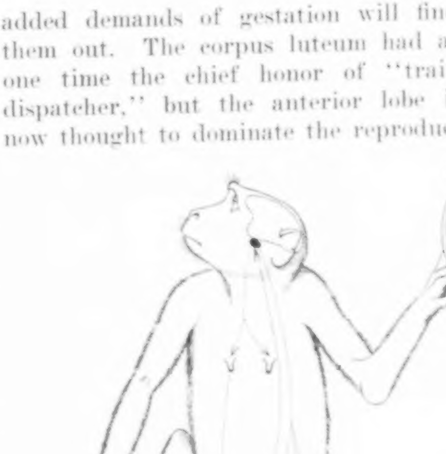


FIG. 17. OUTLINE SHOWING THE INTERPLAY OF SOME OF THE ENDOCRINES IN PREGNANCY.

tive functions of the body through its chemical messengers sent by the blood stream to the various organs.

Let us now return to the egg. For several days it floats free in the uterine cavity. About the eighth or ninth day in the monkey it becomes sticky and attaches somewhere near the upper end of the uterus. It immediately begins to dig in—it becomes a true parasite upon the mother. The maternal tissues melt away before the erosive action of the tiny egg, which must tap the mother's blood supply. In the monkey it becomes half buried (Fig. 13), in the human species entirely so. It would go deeper but for the fact that the decidua, just referred to, walls it off (Fig. 18) to prevent its over-riding the bonds of safety on the part of the villi, those feeding tentacles or suckers that sink into the maternal tissues. The villi contain embryonic blood vessels and dip into the maternal lymph spaces, absorbing the life-giving material. Pieces of villi may break off and enter the maternal blood stream, setting up reactions, partly beneficial, but in excess, detrimental.

As the embryo and its placenta grow they make greater and greater demands, sending out chemical messengers that call out tremendous responses on the part of the mother. The muscle cells of the uterus increase fifteen fold in size, the connective tissue becomes stronger, more succulent, expansible, rejuvenated. Cervix and vagina are prepared for a birth canal by similar changes. Means are suited to ends in a most marvelous fashion. Only a beginning has been made by anatomy and physiology in the elucidation of cause and effect in the processes by which a baby is nurtured and born.

The culminating enigma is the cause of birth. At the physiological moment, as yet predictable only within wide limits, the fetus becomes a foreign body to be expelled. For twelve days in the opossum (Fig. 19), a month in the rabbit, six lunar months in the monkey (Fig. 20) and ten in man, two years in

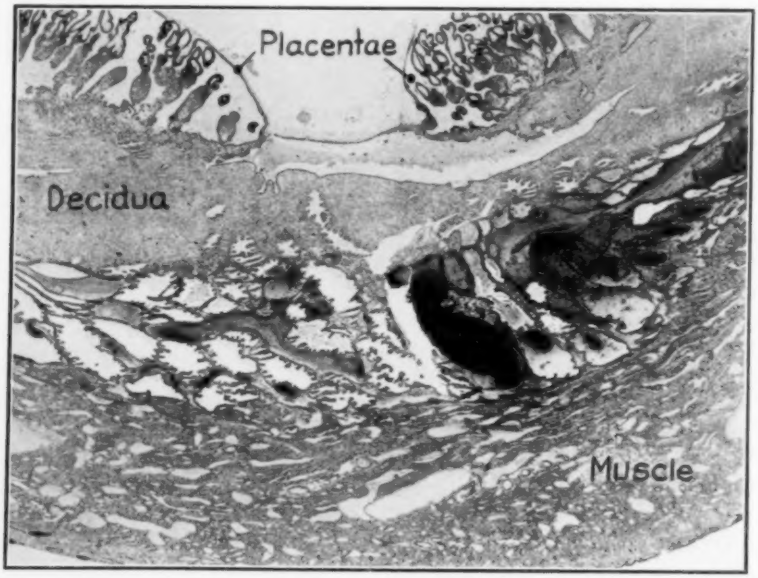
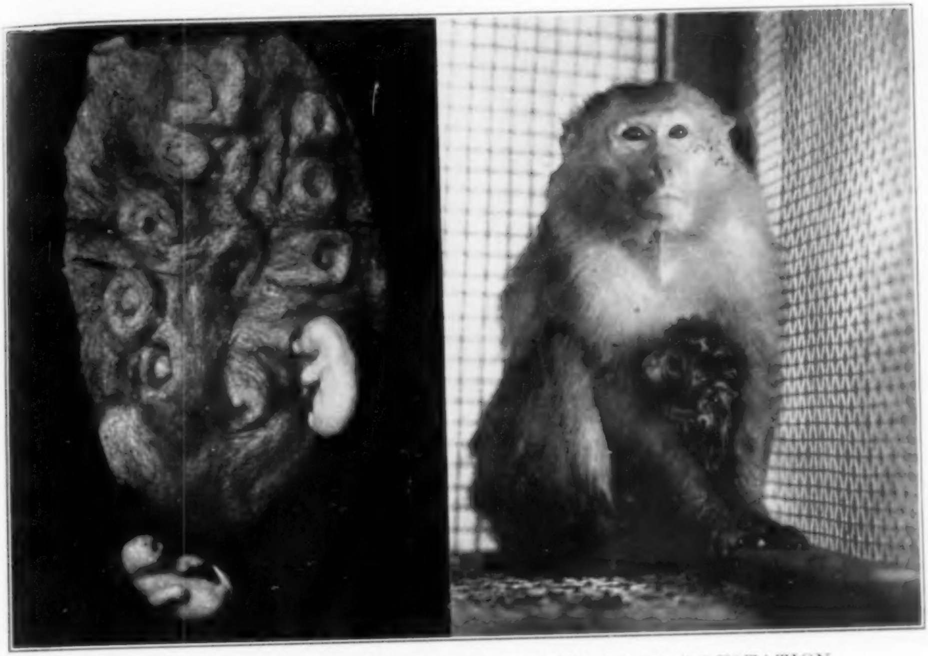


FIG. 18. A PORTION OF THE UTERUS WALL AND PLACENTA OF MONKEY ON THE 29TH DAY OF GESTATION, SHOWING DECIDUAL BUFFER.

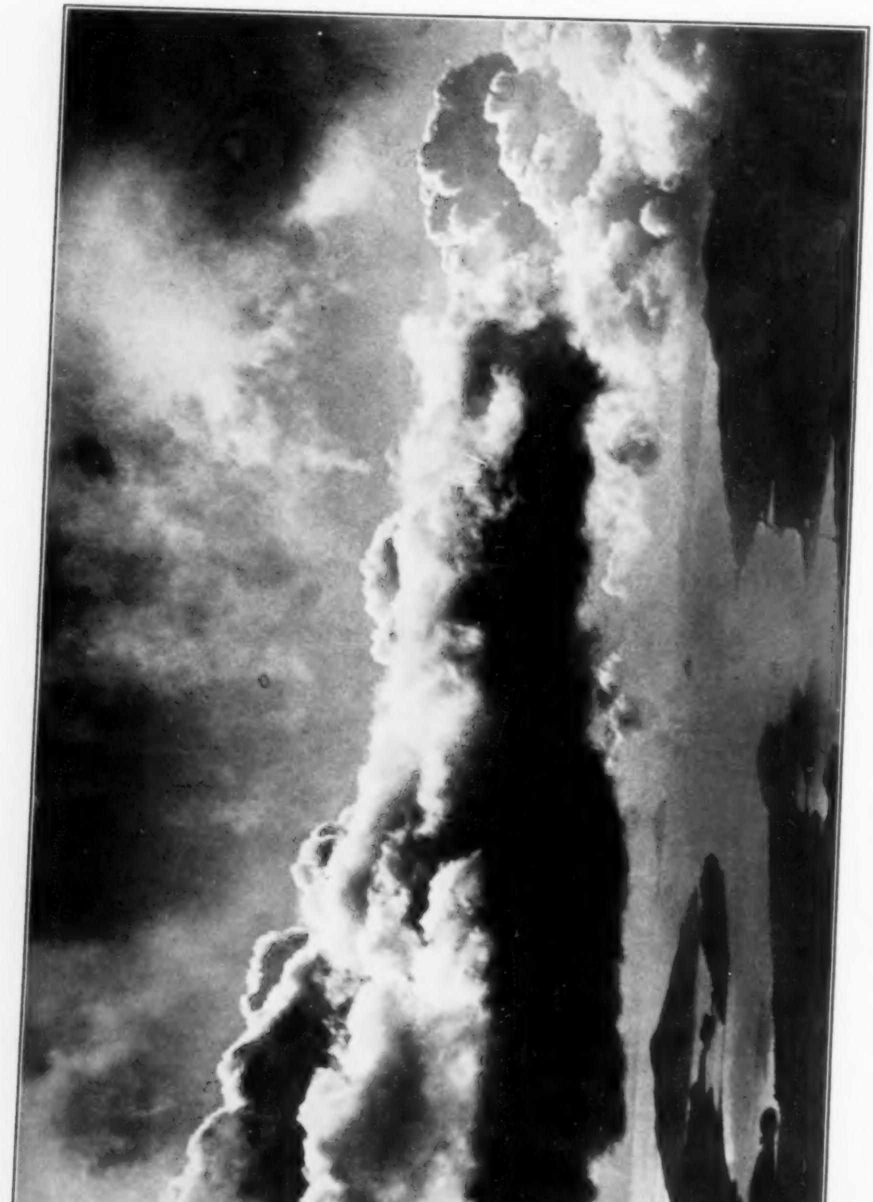


FIGS. 19 AND 20. TWO EXTREMES IN THE SPAN OF GESTATION

FIG. 19. TWO OPOSSUM POUCH YOUNG ABOUT A WEEK OLD, NATURAL SIZE. THE OPOSSUM IS BORN 12½ DAYS AFTER CONCEPTION. FIG. 20. NEWBORN BABY MONKEY, STILL WET; GESTATION SIX LUNAR MONTHS.

the elephant—for a limited time the fetus is a welcome guest, like an organ of the mother's body. Without any warning, so far as we now know, the zero hour arrives, after which pain gives way to the joy of motherhood. We are experts in reading the calendar, but on the *why* of the onset of labor Aristotle was as wise as we are to-day. It should be added, however, that important results are promised in this field from a study of uterine motility in relation to the endocrines.

More is known about the cyclic monthly changes in the absence of pregnancy. Each cycle is an abortive pregnancy which recapitulates gestation in miniature. The cause of the periodicity is doubtless a complex interaction of the glands mentioned in connection with the care of the egg and its nutrition and expulsion, the ovary and the anterior lobe occupying the center of the stage. Thus under the influence of the anterior lobe a follicle grows; it ruptures, liberating follicular fluid; this is resorbed and fires the anterior lobe to new action, and the follicle becomes the corpus luteum; this dies and a cycle is started anew. The egg rapidly dies, too, unless fertilized, perhaps in only a few hours. If so it exerts no influence and another moon must pass before another dies—or lives to join the immortal stream of protoplasm that began when life began and will continue till life ceases.



—*Photograph by Professor McAdie*

FOG CHANGING TO CUMULUS CLOUD.

ONE HALF HOUR MADE A DIFFERENCE BETWEEN A DENSELY FOGGY MORNING AND BRIGHT SUNSHINE.

THE CONTROL OF FOG

By Professor ALEXANDER McADIE

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If you ask some prominent astronomer concerning the nature of the stars, he will quote inconceivably high figures for stellar surface temperatures, also equally appalling data for densities at the centers of stars. Ask another distinguished astronomer and he will correct the earlier figures, explaining that his colleague doubtless worked from the surface of the star inward, whereas in his judgment the proper procedure is to begin with values at the center and integrate outward to the surface. Consult now some authority on physics familiar with the basic equations, and he will point out that even the minimum values given are inconsistent with established thermodynamic laws. In short our authorities on stellar structure today are at variance; and in Europe are somewhat emphatic in protesting views other than their own. American astronomers say less and seek further observational data. One of the most prominent says "he knows that he doesn't know"; which gives most of us who are in the rear guard great satisfaction.

But while there may be confusion in estimates of star structure and conditions, all astronomers and astrophysicists agree that the stars are stupendous gas houses, burning furiously. Any object drifting within millions of miles of one of these vast storehouses of blazing gas would be shrivelled and scorched instantly, so great is the heat. Our familiar friends of night, so constant and so dependable, are in reality only gigantic flames. Like so many lighted candles they must in time burn themselves out, leaving nothing. Our universe and presumably the farthest galaxies are blazing furiously; and heat is being diffused in space at a rate beyond human conception.

All creation is afire; *all but the earth*, for the serio-comic aspect of the situation is that amid all this lavish waste of heat, the little speck of matter on which we live is slowly freezing to death. Unlike the stars it is non-gaseous and incapable of producing its own supply of heat, even enough for home consumption. Man and all his works are doomed to be entombed in a wall of ice. Civilization will end in a never-to-be-broken sleep, under a great sheet of solid frozen water. Somewhere the last man (let us hope in an attitude of protecting the last woman) will throw up his hands and be overwhelmed in the ice flood. Nothing that human agency can devise will melt or stay the encroaching, all-embracing universal glacier. The astronomical forecast presages a cold fate, a chilled faith and a congealed hereafter; and Dante's uttermost hell will be right here on earth and not beneath as the poet imagined.

The five interglacial intervals that the earth has already experienced in the Pleistocene Ice Age are but the advancing and retreating waves of a slowly rising tide, ultimately submerging all. Notwithstanding this cheerless prediction of ultimate frigidity, we can afford to be cheerful, for astronomers are often confounded, and remarkable and unexpected discontinuities do occur in the behavior of celestial bodies. More pertinent still is the fact that the earth loses its heat at so slow a rate that millions of years must elapse before the freezing point is reached. Perhaps the second law of thermodynamics, the law

—*Photograph by Professor McAdie*

FOG CASCADES.

LOW SEA FOG AS DISTINGUISHED FROM GROUND RADIATION FOG. THE AVIATOR MUST PICK AND CHOOSE IN LANDING.

that insists on the running down and heat death of every thermal engine, may meet with a jolt, and actually show reversal. So there is no need of worrying about our ultimate fate.

If now we venture to make the novel assertion, not yet advanced by any geophysicist, that a fog bank is in its way the forerunner of an ice cap, we shall not be far astray. For the essential difference between ice, water and vapor, invisible or visible, is simply a matter of molecular freedom; that is, the excursions of the molecules of this mixture of hydrogen and oxygen may be described as fixed, fluid and free. Picture a hundred school children in a crowded classroom, quiet and making no noticeable commotion. That is the solid condition found in ice. Now let there be a recess and these hundred youngsters, who for our purpose are molecules, go storming out to play. They jostle each other and run about freely, even as in the liquid water the molecules slide on one another and have a certain freedom of motion. Finally imagine each child to be provided with a moth airplane painted a dirty gray. Now they jump away from the ground and move hither and yon in the air. This corresponds to the vapor state. Let our flying children hug the earth and crowd one another, and we have a condition comparable with condensation of water vapor into cloud or fog. A cloud is nothing but a fog that by virtue of a slight excess of heat has developed a lifting force and so rides high. Conversely a fog is a cloud that is earth bound.

The great glaciers that once swept southward, grinding and crushing everything in their way, were originally compacted and compressed snow fields; and snow crystals are only water vapor molecules that lost heat so suddenly there was no time for assuming the form of a cloud globule or fog droplet. It is as if our school children painted their planes a beautifully pure white, arranging also to have the wings project like six pointed stars. Let these snowflakes fall gently to earth in innumerable numbers, and accumulating year after year, in Arctic regions, form great rivers of slow-moving ice. Large chunks break off and float away as icebergs moving south.

Few transatlantic passengers, sighting at a distance the glistening crest of a berg, realize that the ice was once warm

water vapor in mid-latitude if not equatorial seas. The molecules springing free because of their heat energy were borne aloft by an uprising air current. As the air expanded and pressure decreased, there was consequent chilling. Crowding together, the vapor particles became a snow cloud. Carried northward on some thermal air thrust, ever cooling, with its store of heat, like life-giving energy, almost exhausted, the flakes fall finally on the far-stretched ice fields of polar regions.

Not inaptly then may we regard fog in a new light, as the forerunner of the ice; the water form that happily did not carry on, that died, so to speak, halfway on the journey from equator to pole or from some local hot source to a cold sink. But it did not lose its capacity to cover and enfold. Its opacity increases, and, like an embryonic ice wall, it can wrap all things in its embrace.

The danger of an ice tomb is not imminent, and we need not think we shall escape taxes, senatorial insurgency, sumptuary laws and all that give spice and variety to life; but the imminence of fog embracement is only too evident and we do not escape its threats of danger. Such a pall makes us suspend for the time being many of the activities of life, and retards others. We read at frequent intervals of the evil-smelling fogs of Flanders and the Dutch lowlands. The fogs of London are a byword; and it has recently been published that on certain days in December, 1930, the loss to shipping in the port of London was at the rate of £1,000,000 for each day of dense fog. But we need not go so far afield for an instance of large loss due to fog. The month of March, 1929, furnishes a striking example. On the 13th it was unusually warm along the Atlantic seaboard. Without doubt many molecules were skipping about over the ocean's level brim; but no human eye could see them. On Thursday the 14th the wind swung around from the west to the east, and so a steady stream of water vapor came rolling in along the coast from New Jersey northward. Later the wind swung to southwest and a murky warm fog settled down over New York City and its environs. Transatlantic liners inbound and outbound were forced to anchor. On Friday the 15th the murk was even worse. Those clever and exceedingly expert fog dodgers, the ferry pilots, decided it was best to abandon all schedules. Commerce was suspended, only a few harbor craft groped their way with constant tooting of whistles.

Even on land vehicles moved slowly.

—Photograph by Professor McAdie

SEA FOG.

TRANSVECTIVE, THAT IS, BROUGHT IN FROM THE OCEAN. TOP OF FOG BANK 500 METERS (1,600 FEET) ABOVE SEA LEVEL. GOOD FLYING ABOVE, BUT BAD FOR LANDING.

—*Photograph by Professor McAdie*

LOW STRATO-CUMULUS.
NOT DANGEROUS, BUT WINDY.

It was the densest, most persistent fog known in twenty years. The daily press gave long descriptions of distressing scenes at railway and ferry terminals. Commuters herded in waiting rooms fretted and swore to no avail. Until near noon on Saturday the 16th, the fog was so dense that objects ten yards distant were swallowed up in the murk. This home-brewed *smog* (smoke-fog) was as murky as a London "pertickler." New Yorkers rising from their beds on each of the three mornings found it unnecessary to pull down the window shades. (In the metropolis it is customary to do so, when starting to dress.)

This was a dirty fog, one of the pea-soup brand. On the first day there were over 200,000 dust particles in every cubic meter of space, on the second day 1,600,000. Just before the end there must have been 6,000,000 dust particles per unit of volume. This means that if one scooped up a handful of the all-pervading, there would be in the catch fully 50,000 dust particles; and on each particle a varnish of water vapor. Small wonder that visibility was poor.

Here was a glorious opportunity to demonstrate the efficiency of fog dissipators, whether by adding heat, spraying with electrified water, or by vigorous fanning, and the injection of streams of turbulent air eddies. Nature, however, scattered the fog, in its own large way. The cure was strenuous and speedy, the brushing so energetic that to many the cure was as nerve-wrecking as the complaint. The whole barrier of fog stuff was blown away in an hour. It was of course our old friend Skiron, warder of the northwest wind, on the rampage. He came on the scene, buffeting with lusty blows the mild-mannered Notos and the muffled Euros, guardians of the south and southeast wind. His mighty breath, in gusts that traveled a mile a minute, turned all things topsy-turvy. He respected neither gods nor men, nor even a procession to a saint. For swinging up Fifth Avenue with stately steps and slow, the customary St. Patrick's Day parade had just reached the reviewing stand. Then it was that Skiron turned Sassenach. Like the Assyrian of old he came down on the fold. In a jiffy he knocked off hats from every head. A thousand silk toppers of assorted vintages went tossing on the breeze. They were borne skyward but not on the wings of song. Coat tails, hitherto sedate enough, designed to cover substantial parts of the human anatomy, became possessed of seven devils. With hilarious impudence they flapped in places where they were not wanted. Badges were torn from the imposing fronts of the city fathers; and stern-faced color guards, strong to face the wind, realized that whichever way they turned they had better have turned some other way. Nor did the ruffian, Skiron, spare the skirts of sisters and sweethearts. Graceful draperies sprang into life as parachutes, revealing much not usually disclosed to the eye of man. But the fog was conquered. Farther north, as in Boston, the turbulence developed into a thunderstorm; illustrating perhaps even more directly the instability of air masses in which large quantities of warm water vapor are underrun by strong cold air streams.

These commotions are found quite frequently in the clouds, at moderate heights above ground. We sometimes call these malevolent outbursts squalls, and they constitute one if not the leading menace to safety in flying. Fogs, squalls, lightning and ice coats must all be reckoned with; and in each and every case we find water vapor as the initial disturber of the peace. It is the vapor molecule that starts the row. Cold air underrunning warm air may produce invisible air whirlpools; but when the warm air is heavily laden with water vapor, and the molecules of the latter are ordered as it were to quit instantly

their free excursions and get back at once into the liquid or solid state, then trouble begins, with a black-browed cloud, or if close to ground a dirty fog. Eddy currents, technically called *anakatabats* (up and down rushes), make a veritable aerial whirlpool. It was in such a commotion that the good ship *Shenandoah,* daughter of the stars, was caught and flung now down, now up, until the control cars and the main ship were wrenched apart. So, too, with the *R 101,* while the chief cause may have been leaking gas containers, there is no doubt that down rushes in the fog caused such severe bumping that fire started and the catastrophe followed. Nor are planes exempt. The best of pilots may find himself unable to dodge evil-looking clouds, for what seems lightest may become darkest in a moment.

Ice will form from sub-cooled water and adhere to the propeller as well as to the wings, ultimately forcing the plane down. Caught in a down rush the plane may drop a thousand feet in a minute, only to shoot up again with equal velocity. In nearly all the long distance flights from Great Britain to India and Australia, there are vivid descriptions of struggles with squalls. And every balloonist who has survived being caught in a thunderstorm can tell a graphic tale of the way in which these currents tossed the balloon about.

But the fogs of the Great Banks are not this way, some one will say! True, they are not; and there are many kinds of fogs. It is a rather quiet but persistent pall of fog that overlies the Grand Banks. Faith, we are told, is the substance of things hoped for, the evidence of things unseen; and it requires faith, when crossing the Atlantic and plugging on during the third and fourth days through an unending cover of fog, to believe that the sun is still high in the heavens. Soundings have been made, however, in this fog, and we know that the layer is not very thick, in fact, some of the tall buildings in New York, if it were possible to remove and erect them above the Grand Banks, would have the upper floors flooded with sunlight. Looking down on the far-flung sea of ruffled fog, with sun-tipped billowy crests, the occupants of the upper floors would chant in chorus:

> "If seven maids with seven mops
> Swept it for half a year!
> Do you suppose," the Walrus said,
> "That they could get it clear?"
> "I doubt it," said the Carpenter,
> And shed a bitter tear.

We share the Carpenter's doubts. Some kinds of fog can be dissipated, as will be shown later; but in the case of the Grand Banks, the supply is so large that the contract is beyond our undertaking.

It has been seriously proposed to spread a film of oil over the ocean, and thus prevent evaporation, strapping the molecules down tightly to the water, as it were. Then, no matter how much heat was abstracted, there could be no vapor to condense and hence no fog. But there would still remain the necessity of damming two great rivers of air, one bound northward heavily laden with free and far-skipping molecules, and the other blowing from cold, bleak Labrador, crowding the warm current. Sir Napier Shaw told us some years ago in his "The Air and its Ways" that the bulk of the water in an Atlantic fog (and it takes only a thimbleful of water to make a hogshead of fog) came from the south and not as hitherto accepted, from the water in the vicinity. Therefore, as we can not fence off Skiron from Notos, the sweet-tempered bearer of the water jug, we can not prevent the pushing and jostling marked by the formation of fog. Far to the east, Notos pursues the even tenor of his way, and gives warmth to the British Isles—a warmth quite generally but erroneously attributed to the Gulf Stream.

Whenever cold and warm streams meet, be they of water or air carrying water in the invisible form, there will fog form; and the density be proportional to the temperatures involved. Officers of the Ice Patrol say that it is easy to recognize the boundary between polar water and the Gulf Stream. Off the tail of the Grand Banks these currents abut with such remarkable distinctness that the wall—the Cold Wall—can sometimes be detected, extending down to a depth of 200 fathoms. The juxtaposition of currents with marked temperature contrasts results in startling atmospheric anomalies. A steamship may at times run into fog so dense that the captain on the bridge can not see the bow; and conversely we have well-authenticated cases of ships emerging from a wall of fog with the forecastle in clear air and the stern in fog. It would seem to be beyond our power at present to dissipate fog of such density.

Likewise, we can hardly hope for success in scattering the fog of the West Coast, the tide that, for example, pours through the Golden Gate every summer afternoon. This is due to upwelling cold coastal water overlain by warm moist air. An actual attempt to clear away the fog at San Francisco by discharging electricity of high voltage was not successful, but it must be remembered that here again, as off the coast of Newfoundland, the vast supply tends to mask any perceptible diminution by artificial agencies. Nature does, however, dissipate the Golden Gate fog every day in an exquisite way. One has only to climb the Berkeley Hills and look down on the fast-fading fog. The valleys supply the requisite heat, the fog droplets change into fast-flying molecules, escaping from their thraldom, and nothing remains but the velvet touch of the summer breeze.

Of the various methods of dissipating fog that we have seen and tried, that of spraying with electrified water jets seems to be the most effective. Electrified sand and air are slower. Electrified smoke has not yet been tried to any great degree. In the laboratory we have no difficulty in clearing away smoke by passing a spark of some length across the container. Two or three seconds will suffice to clarify a dusty, smoky atmosphere. Out in the open, however, we have not met with the anticipated success. We have examined microscopically the dust content of air before and after the passage of near lightning, also real lightning. The former experiments, tried and repeated through the courtesy of the General Electric Company at their high tension experimental laboratory, involved a flash four or five meters in length with a voltage of over two million. Likewise with real lightning we have not found the clearance to be as marked as anticipated. The clarification of the air, following a thunderstorm, which every one can notice, is due more to mechanical replacement of air than to the tremendous throwing effect and repulsion accompanying high potential discharges. But further experimentation is necessary, where conditions are more under control of the experimenter.

We believe, however, that it is quite practicable to dissipate the shallow ground radiation fogs of morning, following a still clear night with characteristic temperature inversion. Indeed, some of these fogs, as on August mornings over the water approaches to New York (and of course at other important commercial points), could be dissipated without great expense, utilizing, for example, the powerful streams of the fire boats. Electrified spray from these mighty nozzles would not only wash a channel in the fog, but cause the fog droplets to coalesce and agglomerate and drop as a drizzling rain.

The subject is not to be dismissed without a short reference to the good

side of fog embracement. In naval maneuvers and mimic warfare, the planes throw out a smoke screen, and this can rest on the surface of the water or hang high in air to hide the bombers. The use of a fog screen as a defense can be traced back to mythological times. Does not Homer picture the infuriated Achilles about to hurl a rock so big that two men could hardly lift it, at the head of Aeneas, who had foolishly hurled his spear at the mighty leader of the myrmidons? Then it was that a certain goddess wrapped the future hero of Vergillian verse in a fog; and the son of Peleus knew not where to throw the rock. So, too, with Nelson and Napoleon. The latter, fleeing to Paris from Egypt, fearful of consequences at the hands of an angry Directorate, slipped by the watchful admiral in the fog. The Little Corporal got by, else Austerlitz and Waterloo had not been spread on history's pages.

And there was one day in the World War when fog overpowered both sides. A full moon lit up the battle front from Loos to Fresnoy on the night of May 6, 1917. Next night it rained, but the guns never ceased firing. It was the supreme artillery effort of the war, and along a fifty-mile front every available gun was in action. Then came dawn, with the light dimmed by gathering mists. As the minutes passed, the fog thickened. Without sound or murmur a wall of white swallowed the contending armies. Mute but masterful, the fog countermanded all battle orders. The roar of a thousand batteries gave way to stillness. And we venture to think that on both sides a suggestion to employ fog dissipators would not have been received with enthusiasm!

THE HEREDITY OF THE BLOOD GROUPS

By W. V. LAMBERT

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THE study of heredity in man presents one major difficulty not encountered in other species. The direct genetic approach being impossible, students of human heredity have to rely upon mass statistics, and upon the often fragmentary record of family pedigrees as the source of data for their conclusions. It seems remarkable, therefore, that the heredity of obscure biochemical properties of the blood should be among the best known of all inherited human traits.

For the discovery of these properties, the human blood groups, the world is indebted to Dr. Karl Landsteiner, a discovery for which he was awarded the Nobel prize in medicine in 1930. This award has, naturally, focused the attention of many people upon a subject that for years has been of fascinating interest to the biologist, and one which is still claiming the attention of hundreds of workers in biology and medicine. But what are the blood groups, and what further significance have they in biology and medicine to justify their continued study by such a large group of investigators?

The blood groups occur in man as constant, inherited, biochemical entities existing in the blood. The work of Landsteiner and his students was to show that the blood of all people could be placed in one of four distinct groups. For the recognition and study of the blood groups one of the most generally used of the immunological processes, namely that of agglutination, is employed. Since the recognition and study of the blood groups hinges upon the mechanism of the agglutination reaction, an understanding of their nature and inheritance must be based upon some knowledge of the mechanism of agglutination.

THE PHENOMENON OF AGGLUTINATION

If killed typhoid bacteria are injected into the blood stream of a normal rabbit at three- to five-day intervals for several weeks, this animal will form reacting substances in its blood stream against this foreign bacterial protein. These substances are known technically as "antibodies." If, after a period of about two weeks following the last injection, blood is drawn from the animal and the serum has been obtained, the phenomenon of agglutination can easily be demonstrated. The demonstration consists in adding to a suspension of typhoid bacteria contained in physiological saline solution, a small quantity of the serum. If the test-tube containing the bacterial suspension plus this serum is placed in an incubator and kept at body temperature for a few hours it will be found upon reexamination that the bacteria have flocculated or "agglutinated" and settled to the bottom of the tube, whereas the control tube, to which no serum was added, has undergone no change; that is, the bacteria will still be in suspension in the saline solution of the control tube.

The same phenomenon may be demonstrated microscopically. If some of the bacterial suspension plus the serum is placed on a slide and examined under the high power of the microscope the bacteria will be found, after a few minutes, to be aggregating into clumps. No such clumping is to be found, however, if one examines in this way some of the control suspension, the one to

which no anti-typhoid serum was added.

This reaction is a highly specific one, the serum of the animal containing antibodies in any appreciable degree only for typhoid bacteria. This high specificity is dependent upon the nature of the protein peculiar to that one species of bacteria, and this specificity is so great that the agglutination test is one of the best of the routine laboratory tests for diagnosing certain diseases.

The bacterial or cellular suspension used for such agglutination tests is known technically as the "antigen," and the flocculating or agglutinating substance present in the serum as the "agglutinin."

thus corresponding to the "antigen" for the bacterial cells previously mentioned.

The interrelations of the four blood groups with each other will be made clear by reference to Table I. It is apparent from this table that the serum of no blood group agglutinates its own cells, and, further, the serum of group AB does not agglutinate the cells of any other group. The cells of no group are agglutinated by the serum of the blood in which they are continually bathed; while the cells of group O are not agglutinated by the serum of any group.

In cases of blood transfusion a healthy individual of the same group as

TABLE I

Group*	Serum agglutinates blood cells of groups	Blood cells agglutinated by serum of groups	In transfusion	
			Can give to groups	Can receive from groups
O	A, B, AB	No group	O, A, B, AB	O
A	B, AB	O, B	A, AB	O, A
B	A, AB	O, A	B, AB	O, B
AB	No group	O, A, B	AB	O, A, B, AB

* Groups O, A, B, AB correspond, respectively, to Jansky's groups I, II, III, IV.

Usually, the blood does not contain agglutinins unless their production has been stimulated by the presence of foreign protein in the tissues of the animal, either by injection or through the invasion of the tissues by bacteria, as in the case of disease-producing microorganisms. Likewise, an animal will not develop antibodies against its own tissues and ordinarily not against those of other animals of the same species.

However, there exist in the blood serum of man normal or natural agglutinins which will cause the clumping of the blood cells of other people. These natural agglutinins in the blood serum of man are known as "iso-agglutinins," while the blood cells which show this capacity for agglutination are known technically as the "agglutinogens";

the recipient is chosen for supplying the blood. This is necessary, for if the cells of the donor are agglutinated by the serum of the recipient of the blood, agglutination will occur within the blood stream, with the subsequent danger of the formation of clots in the circulatory system. Since, however, the cells of group O are not agglutinated by the serum of any other group, it is possible to transfuse the blood of an individual of group O to an individual of any other group. Individuals of group O are, therefore, known as universal donors. Since the serum of group AB does not agglutinate the cells of any other group, individuals belonging to this group are known as universal recipients. Agglutination following transfusion is caused by the recipient's

serum and not by the donor's serum, as the donor's serum is too much diluted in the recipient's blood stream to cause agglutination. In actual practice an individual is chosen as donor that belongs to the same blood group as the recipient, rather than a person belonging to group O. This eliminates any possible danger from agglutination of the recipient's cells by the donor's serum, and from other possible differences that may exist between the two groups.

In medicine and surgery this information has been of great practical significance, for it put the operation of blood transfusion on a scientific basis, and thus immediately eliminated most of the untoward results that frequently followed this operation. To-day blood transfusion is used extensively, whereas previous to the discovery of the blood groups it was rarely used.

The agglutinogens, that is the blood cells which show the capacity for clumping, are constantly present in the blood stream throughout life, but the agglutinins do not develop until some time after birth. No clear explanation of this delayed appearance of the agglutinins has been advanced.

Evidence has been brought forward in the last few years which clearly indicates that additional agglutinating elements are present in the blood of some individuals, while many observations have shown that a considerable variation exists in the strength of the agglutinins in different bloods. However, since there is no indication that these additional agglutinating elements occur independently of the main groups, it is not necessary to make any change in the present system of grouping, but merely to consider the possibility of subgroups within the four main groups.

The Inheritance of the Blood Groups

Landsteiner reported his discovery of the blood groups in 1901, but not until about eight years later was it suggested that the blood groups might be subject to the laws of Mendelian heredity. Ottenberg and Epstein first made this suggestion in 1908, and Von Dungern and Hirszfeld established the fact beyond a doubt in 1910. To-day, the manner of inheritance of the blood groups is perhaps the most clearly known of all the inherited traits in man.

According to the explanation of Hirszfeld and Von Dungern, the inheritance of the blood groups could be explained upon the basis of two pairs of independently inherited Mendelian genes. Studies made during the last five years, however, have tended to disprove their conclusions; and it seems more likely, as a result of recent studies, that the inheritance of the blood groups is dependent upon the existence of three multiple allelomorphs. Evidence for this conclusion will be presented following a discussion of the method of the inheritance of the blood groups.

According to the modern conception of heredity, all inherited characters depend for their expression upon factors or genes which are transmitted from generation to generation in the nucleus of the reproductive cells, male and female alike. Furthermore, these genes are carried on the chromosomes, these being the deep staining bodies found in the nucleus of all cells. The genes may be thought of as minute packets of chemicals located in the chromosomes, each gene always occupying the same position on the chromosome upon which it is carried. In the individual the chromosomes are always associated in pairs, one member of each pair having come from the paternal germ cell or spermatozoön, and the other member from the maternal germ cell or the ovum. In man there are twenty-four such pairs of chromosomes, the two members of each pair resembling each other in size and shape, but differing in their morphology from the other pairs.

The twenty-four pairs of chromosomes may be thought of as twenty-four sets of twins, each set of twins being identical, but differing from every other set.

As the chromosomes are the bearers of the hereditary factors, and they are always present in the individual in pairs, then the hereditary factors, which occupy the same location in like chromosomes, must also be present in pairs. The members of such a pair of factors are known technically as "allelomorphs." Hence, allelomorphs may be defined as the genes that occupy the same position in a pair of like chromosomes. Any one individual, therefore, can not have more than two allelomorphs for any one character in its germ plasm.

If the genes occupying a given locus of the chromosomes of a species are all alike, no hereditary variation in the character governed by those factors is shown. Sometimes, however, internal rearrangements in these genes occur, and once this happens the stage is set for the appearance of a new character in the individuals of that species. These gene rearrangements are known as "mutations."

In some species many such mutations in the genes occupying a certain locus in the chromosome have been known to occur, each giving rise, when present in the pure or homozygous condition, to an entirely new character. Such a series of changes in the genes occupying one locus of a certain chromosome give rise to what are technically known as "multiple allelomorphs." Obviously, more than two members of any such series of allelomorphs can not be present in one individual, but in other individuals of the species the various other combinations are possible.

The inheritance of the blood groups in man is governed by three such allelomorphic factors. The genetic formulae for the various blood groups are shown in the following way.

Blood group	Possible genetic formulae of individuals in each group
O	OO
A	*OA, AA*
B	*OB, BB*
AB	AB

Group O is the recessive group, all individuals of this group being homozygous for gene O which is the ultimate recessive gene of these three allelomorphs. People belonging to group A may have one of two possible genotypes, those homozygous for gene A, or those of the formula AO (heterozygous). Since gene A is dominant over gene O, the blood of an individual of the formula AA gives exactly the same type of agglutination reaction as an individual of the formula AO. Likewise, gene B is dominant over gene O and the individuals of this group are of two genetic formulae, either OB or BB. Gene A, however, is not dominant over gene B so that individuals having the formula AB possess blood which gives an entirely different agglutination reaction than the blood of the other three groups.

As previously noted agglutination occurs as the result of the interaction of two blood elements, the agglutinogens of the cells and the agglutinins of the serum. No blood contains the agglutinins that will cause the clumping of its own cells, so it must be presumed that the factors governing the inheritance of the blood groups in man must control these two reciprocal phases of the blood. Thus, factor O, when homozygous, gives rise to an individual containing no agglutinogens in the blood cells, although the agglutinins in the blood serum of this individual will agglutinate the cells of any other group. Factor A, results in the production of a blood carrying agglutinogens A and serum agglutinins that will cause the cells of both groups B and AB to agglutinate. Factor B, on the contrary, directs the development in a different way, so that

individuals carrying this gene have agglutinogens B in their blood cells and the agglutinins in their serum that will cause the clumping of the cells of groups A and AB. And finally, genes A and B acting together produce individuals whose blood cells contain agglutinogens A and B but whose serum contains no agglutinins.

The interrelations of the two phases of this system are not clearly understood. It seems certain, however, that if the inheritance of the blood groups is to be explained on the basis of triple allelomorphs that the same genetic factors govern both phases of the system. Otherwise, some co-ordinating mechanism must be present that would always insure that blood contained no agglutinins for its own cells. Such explanations have been offered, but Snyder[1] has pointed out rather serious objections to them. If the above explanation is the correct one, it might be assumed that the agglutinogens, which are present at birth, are responsible in some way for the development of the agglutinins, since the latter do not appear in the blood stream for several months following birth. A final explanation of these relations must await further analysis.

The older hypothesis, advanced by Von Dungern and Hirszfeld to explain the inheritance of the blood groups, assumed their inheritance to be dependent upon two pairs of genetic factors, the members of each pair residing in a separate set of chromosomes; factor A and its allelomorph, a, carried on one pair of chromosomes and gene B and its allelomorph, b, on a second pair of chromosomes. The various genetic formulae for the four blood groups according to this hypothesis are shown in the following scheme.

[1] L. H. Snyder, "Blood Grouping in Relation to Clinical and Legal Medicine." Williams and Wilkins, Baltimore, 1930.

Blood group	Possible genetic formula of individuals in each group
O	aabb
A	AAbb, Aabb
B	aaBB, aaBb
AB	AABB, AaBB, AABb, AaBb

The main genetic difference to be observed between the two hypotheses is that group AB contains four genotypes or genetic formulae according to the last hypothesis, while it contains only one in case of the triple allelomorph hypothesis. In both cases it is necessary to assume that the same genetic factors are responsible for the development of both the agglutinogen and agglutinin phases of the blood groups.

The evidence in favor of the triple allelomorphic hypothesis, which is the generally accepted one now, is mainly of two sorts. The first source of evidence comes from a statistical study based upon the actual numbers of the four blood groups present in any population, as compared with the numbers expected. In every race studied to date the agreement between actual and expected is closer for the triple allelomorphic hypothesis than for the hypothesis of independent inheritance. The second line of evidence is from the actual study of the blood groups of children produced from unions of people with known blood types. According to the hypothesis of two independent pairs of factors, marriages between people of group O with AB should give some children in each of the four groups, namely O, A, B, and AB with the majority of the children being in group AB. On the triple allelomorphic hypothesis such matings should produce only children belonging to groups A and B (see Table II). The actual results from a study of many such families confirm the latter hypothesis, it being demonstrated in several of the few cases observed where O and AB

children were produced, that these were the result of illegitimate unions.

TABLE II

Blood group of parents	Possible blood groups in children*
O×O	O
O×A	O, A
O×B	O, B
O×AB	A, B
A×A	O, A
A×B	O, A, B, AB
A×AB	A, B, AB
B×B	O, B
B×AB	A, B, AB
AB×AB	A, B, AB

* Calculated on basis of triple allelomorphic hypothesis.

Two other hypotheses have been advanced to explain the inheritance of the blood groups, but neither one fits the facts as well as the two hypotheses discussed. For a discussion of these hypotheses the reader is referred to the previously mentioned book by Snyder.

The Blood Groups in Relation to Other Traits

The relation of the blood groups to other inherited characteristics in man has stimulated much interest among biologists, especially among the medical fraternity. The inevitable result has been that many claims have been advanced that the blood groups show a genetic linkage with certain of the other inherited traits in man. Most of these claims have been unsubstantiated, and many of them, as Snyder has clearly shown, were based upon a misunderstanding of the fundamental concepts of linkage. In no case has the existence of a clear cut case of linkage with any other trait been demonstrated. This is not surprising in view of the relatively small number of inherited characters known for man and the large number of chromosomes. To show linkage, that is a tendency for two characters to stay together in inheritance from generation to generation, the two sets of factors governing the development of the two characters would have to be carried on the same pair of chromosomes. Since there are twenty-four pairs of chromosomes in man it is not to be expected that many such linkages will be found, especially when most of the family pedigrees suitable for the study of a certain human trait do not furnish any data relative to the linkage of this trait with other characters. Obviously, such linkages exist but the methods available are not suitable for their detection and study.

Much study has, likewise, been made upon the blood groups during the course of various diseases. As a result, claims have been advanced that the blood groups were influenced by certain pathological conditions. All of these claims have been questioned by other students and at the present time it may be safely concluded that no definitely proven relations exist between any pathological condition and any one blood group. The blood groups are very constant elements and seem to be little influenced by changes in the physiology of the body processes.

The Medico-legal Aspects of the Blood Groups

The medico-legal applications of blood groupings are based upon the fact that a child can not possess an agglutinogen unless it be present in at least one of his parents. Once the blood group of each parent is known it can be predicted in what blood group or groups the children of this pair can belong. Thus, in cases of disputed parentage, the evidence obtained from the blood groups of the persons concerned can never prove that a certain person is the parent of the child in question, but they may show that such a person could not

have been one of the parents. The facts are shown in Table II, in which the expected results are given for unions between people of the different blood groups.

From this table it is apparent that if both parents belong to group O the children must, likewise, belong to group O. If one parent belongs to group O and the other to group AB, their children could belong to either group A or group B. In a similar manner the resulting blood groups for all other possible unions are given.

Some exceptions to the expected results from certain unions have been reported, but it is interesting to note that most of these exceptions are found in the reports of the first students of the blood groups. Many of them are probably explainable by faulty technique or possibly by mistakes in the observations of the workers. In some cases, also, the individual in question was definitely known to be the offspring of an illegitimate union. These mistakes are relatively very few when compared with the number of observations that do correspond with the expected results. The only other possible conclusion is that the laws of Mendelian inheritance do not apply in the simple way just discussed to the blood groups. However, since such a large body of facts is at hand that conforms to expectation, it is logical to assume that the errors reported were due to the first two reasons mentioned.

The Racial Distribution of the Blood Groups

Anthropological interest in the blood groups arises from the possibility of determining the origin and relationships of the various races of the world through a study of the distribution of the four blood groups in different peoples. The percentage of the four blood groups varies in different races, and the results show that this distribution is to some extent correlated with geographical distribution. Thus, the work carried on by the Hirszfelds shows clearly that the peoples of western Europe contain a larger percentage of individuals of groups A and O. The A and O groups decrease in relative frequency as one moves eastward, while the percentage of the B group increases in frequency. Some idea of the distribution of the four blood groups in the various races may be obtained from Table III.

TABLE III

Location and nationality	Percentage distribution of the blood groups[1]			
	O	A	B	AB
Western Europe—				
English	46.4	43.4	7.2	3.0
Dutch	42.0	44.0	9.0	5.0
Germans	38.4	43.2	12.9	5.4
Swedes	38.1	47.3	9.3	5.2
French	43.2	42.6	11.2	3.0
Americans[2]	44.3	40.4	11.2	4.1
Eastern Europe and Asia Minor—				
Russians	33.4	35.9	22.3	8.3
Turks	36.8	38.0	18.6	6.6
Moslem Arabs	33.8	36.8	18.5	10.8
Arabs	43.6	32.4	19.0	5.0
Eastern Europe—				
Japanese	29.5	39.0	21.3	10.0
North Chinese	30.7	25.1	34.2	10.0
South Chinese	31.8	38.8	19.4	9.8
Indians (India)	31.3	19.0	41.2	8.5
Australian aborigines	56.4	38.0	4.4	1.2
Madagascans	45.5	26.2	23.7	4.5
Americas—				
North American Indians	78.7	19.0	1.9	0.3
South American Indians	82.9	12.8	4.3	0.0
Eskimos	80.7	12.9	24.0	4.0

[1] Calculated from data tabulated by Snyder, *loc. cit.*, and L. Hirszfeld, "Konstitutionsserologie und Blutgruppenforschung." Julius Springer, Berlin, 1928.

[2] Largely of Western European origin.

Among the peoples of western

Europe and their descendants, as shown for English, French, Germans, and Americans, the percentage of both blood groups O and A is high, while in eastern Europe the percentage of the O and A groups has decreased relatively. In the people long inhabiting the Americas before the advent of other peoples, the North and South American Indians, the proportions of the four blood groups are entirely different from those observed in Europe and Asia. In the American Indians group O is by far the largest while groups B and AB appear very infrequently.

In view of the percentage distribution of the blood groups observed in the various races it might seem that group O was the original group present in all peoples. Then at some time in the past history of the race the mutation resulting in group A appeared, and this became widely distributed among most of the peoples of the world. Its higher incidence among the peoples of Western Europe, however, would indicate that it probably first occurred among the people from whom the present inhabitants of Western Europe descended. The higher percentage of people of group B in Eastern Europe and Asia indicates that the mutation resulting in group B probably arose at a somewhat later date than the A mutation and probably in the people inhabiting western Asia or Eastern Europe.

In the Americas it appears likely that mutation A has occurred at a relatively late date in the people inhabiting these areas, and that mutation B has made its appearance very late, if at all. It is more likely to be accounted for among the native peoples of the Americas as a result of race crossing with the Europeans.

Racial migration and crossing would of course greatly influence the distribution of the various blood groups among different races; and since racial migration and crossing have taken place extensively among the peoples of the world for long periods of time, the racial distribution of the blood groups does not furnish as suitable material for a study of racial origin and relationships as might at first seem to be the case. The only advantage of the blood groups over other hereditary traits for anthropological studies would seem to be in the fact that in case of the blood groups no conscious selection for the various types is possible.

THE GLORIFICATION OF PARASITISM

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It is an ancient custom for philosophers and sociologists, who know little about parasites, to refer to certain persons and groups as parasites on society. It is only fair that the parasitologist, who knows little about philosophy and sociology, elaborate this theme as one who is familiar with zoological parasitism. From a quarter-century's experience with parasitic Protozoa, tapeworms, flukes, nematodes, mites and parasitic insects, there may be derived certain analogies between these parasites and our social parasites, and from these analogies one may conclude—what one wishes to conclude.

All parasites, from the pallid tapeworms to bright-colored tropical ticks, from the burrowing mites to the swift-darting horse-flies, and from the microscopic malarial crescents to the huge hydatid or the giant kidney worm, have this peculiarity in common—that they feed on living animals larger than themselves. On the basis of food habits, parasites stand in contrast with three other groups of animals. One group is composed of scavengers,—the sedentary oyster, the plaintive sea-gull, and the skulking jackal, the eaters of others' leavings and the camp-followers of decaying death. A second group is composed of predators—the hairy tarantula, the destructive pike, the crushing boa, the swooping eagle, and the fierce leopard, the shrewd and powerful killers of prey. A third group is composed of the more or less peaceable animals that work for a living—the insect-eating birds, the grass-eating sheep, the tree-feeding giraffe, the animals that rustle a living by the industrious collection of large amounts of such small provender as grass and grasshoppers.

The reader will have foreseen the sociological implication of this grouping. The terms used are old and familiar in zoology and in the everyday affairs of life. Most of them originated as terms applied to people, and were later applied to animals other than man. For man is an animal, even though he is prone to overlook that fact and prefers to regard himself as an immortal soul. No question is raised here as to the soundness of his high regard for himself as an immortal soul, but from the standpoint of zoology we are now considering the animal that Linnaeus named or misnamed *Homo sapiens.*

This animal has been said by some philosophers to have, in common with other animals, two great driving forces, hunger and sex. We are not concerned at this moment with sex, but we are concerned with hunger, the need and desire for food. As man solves his food problem, which by expansion is the problem of making a living, so he classifies himself for our purpose as a scavenger, a worker, a predator or a parasite. It should be repeated at this point that these comparisons which are given here are mere analogies, but analogies are sometimes of interest and value, as are fairy stories and parables. They are not even new analogies; the ancients saw them and applied similar animal names to certain men, and names of human groups to certain kinds of animals, on the basis of certain characteristics in common.

Our solution of the problem of making a living in this bewildering world is not always in terms of a conscious selection of a life as scavenger, worker, predator or parasite. Life is not that simple, decisions are not that conscious,

and our control of events is usually much less certain. Nevertheless, the mental processes corresponding to such conscious selections are usually present.

The person of feeble will or unhappy circumstance, dominated by the fear of life, or ignorant of the ways of making a living, raised in many cases in the wretched environment of squalid poverty, and thoroughly beset by an ingrained inferiority complex, may select a scavenger's life without consideration of any other possibility. He lacks the hustle or ability of the worker, the courage of the predator, and the ambition, even the aspiration, if you please, and the opportunity of the parasite. He lives, in effect, on the rejected leavings of others, and he and his kind constitute a small group; we hope, a decreasing group.

Most of us elect or are forced into the rôle of workers, the common and simple solution of the business of obtaining food. We have at least a reasonable capacity for hustling a living and we concur, outwardly, in the premise that life is or should be an affair in which we exchange with the world a *quid pro quo* for our living. It is fortunate for the scavenger, the predator and the parasite that the bulk of humanity goes into the group of workers, for the worker furnishes the food on which these others feed. His sweat and toil and industry convert the raw material of earth into food for himself, crumbs for the scavenger, and feasts for the predator and the parasite.

The predator not infrequently shows signs of having frankly reacted violently and unfavorably to the idea of earning a living by exertion, the dull, unromantic and unadventurous business of being a worker. In the lower brackets of society he constitutes the recognized criminal element that exercises its craftiness rather than its muscles, and its wits rather than its intelligence. In the higher brackets of society he constitutes a criminal element that is being more and more recognized as exercising a vicious political and financial force. In their immediate relation to the individual and to the small groups on which they prey, these persons are predators, but in their relation to society and the body politic they might be called parasites. To their victims they are tigers; to society they are lice.

And this brings us to a consideration of the social parasites great and small. Here are those who "toil not, neither do they spin," yet who have comfort, luxury and glory beyond those of Solomon. Here are those who have ambitions beyond scavenging, who have a distaste for work, and who may lack the courage, and in many cases have no need for courage, to pit their wits or brawn against the world as predators. Here are the quacks, the shysters, the fakirs, the wastrels of high and low degree, and here also are many persons of the world's elect, persons who are highly regarded and envied. Some are here by inheritance, election and choice, and some by accident. Some are the products of our curious mental processes, our economic absurdities and our legal fictions. By and large they are a motley group, with this in common, that they do not repay from their own life and living in sound values to the world what the world of yesterday and to-day has given them. Even society itself may play the parasite, and take from its men of genius and its unfortunates without recompense and without recognition.

The youngster who faces the problem of making a living, the broad problem of hunger, will consciously or unconsciously take into consideration the attitude of society towards the groups who have solved this problem in various ways. He will know that society will despise or pity the scavenger, and he will not elect that status; only great personal lack and need will put a man in the ranks of the beachcombers. He will note that the

workers respect themselves and their kind, but he will also note that by and large they are none too well satisfied with the status in which they are established. He will detect the fact that while labor is of recent years not spoken of, even in good society and in ecclesiastical circles, as the curse of Adam, there is, nevertheless, a wide-spread and urgent desire for a status in which one may truthfully say: "I don't need to work another day in my life." A little further scrutiny would bring him to the astonishing conclusion that parasitism is highly thought of in practically all circles of society, and that the parasites are the most highly esteemed of the groups we have named.

That the predators are not a more attractive group follows largely from two things: First, their activities are too obviously and crudely antisocial, and the hand of society is raised against them; second, it takes a certain amount of courage of a sort to be a predator, and the psychologist's quest of the phobias leaves the impression that courage of all sorts, physical, mental and moral, is a rare thing in the makeup of man. Psychology has shed some light on our composition and motivation by showing us the extent to which we are dominated by our fears, but it has shed little light on the problem of how we are to overcome fear and develop courage in adults with their established patterns of behavior. The courage of the human predator is not a very admirable thing, viewed from all angles, and it is perhaps fortunate that this particular brand of courage is not more common. But if the workers of society had more courage of other sorts there would be fewer predators, for the predator's courage, or courage of any sort, can not well be met and matched by fear of any sort.

And so we come to the conclusion that of the various modes of living, parasitism, the life of large income without effort, life without a demand for work, or for a *quid pro quo*, or for courage, is the most highly esteemed. The parasitic worms have set us a bad example, and from the Protozoa up there has been the innate urge in animals to give up the struggle for existence by the escape to the ease and safety of parasitism; and man has followed these examples and yielded to his innate animal's urge to parasitism whenever possible. Is this an exaggerated statement? It would be reassuring to know that it is, to know that in the majority of persons there is not the desire to shirk the struggle for existence, that the majority of persons desire to repay to the world a just *quid pro quo* for the food they eat and the clothes they wear, that the majority of persons are too ambitious, too proud, too honest and too independent to live by the labor of others, but the evidence does not support the idea. The suspicion remains that the fat and flabby life of the parasite, the toilless existence of the tapeworm, fascinates us.

Here is the escape from life with its uncertainties. In a small way we are beginning to tag the persons who elect to escape from life by the route of chronic, needless invalidism, or conscienceless demands on charity, or suicide. In a large way we should realize that the path of choice, the select and favored route of escape from life's struggles and difficulties, personal, financial or otherwise, is the path to social parasitism. We should realize that much of what is taught and urged as ideal, as the ultimate good, by highly thought-of persons in high places, may be translated in the language of biology as the glorification of parasitism.

In defining a parasite we used its habitat and food habits as a basis, and we have considered certain social analogies in connection with hunger, food and the business of making a living. It so happens that the food habits of parasites are closely related to another basic essential of life—the necessity for reproduc-

tion to maintain the species. The reproduction of parasites is a gamble. The parasite plays the law of chances on the basis that if you lay enough bets some of them will win. To maintain a certain species of ascarid, the female worm may produce 30 or 40 millions of eggs. Almost 30 and 40 millions of these eggs will die and go for naught, but it needs only some small fraction of one per cent., say 10 to 100 eggs, to get back to a suitable host and mature, and the perpetuation of the species is assured.

This enormous and wasteful production of eggs is made possible by and correlated with the easy life of parasitism. The ascarid lives in its host's intestine, where it is maintained at a constant temperature, free from the necessity of seeking shade to keep cool or hustling around to keep warm. It is surrounded by food and probably need not, perhaps can not, exercise an effort even at selection of food. Thus provided with a highly nutritious metabolic intake and freed from the need for exertion, the ascarid can devote its energies almost entirely to reproduction. There is the odd chance, so far as ascarids are concerned, that in a host animal there may be no male ascarids to mate with the females present, or *vice versa,* and some nematodes, and almost all tapeworms and flukes, write off this chance by the development of hermaphroditism or parthenogenesis. These parasites are gamblers, but in nature, and without the intervention of man, they usually play a sure thing to win.

It seems then that in addition to their simple solution of the great problem of food, the parasites have successfully solved the great problem of sex. It is a thoroughly dispassionate solution and in complete agreement with the best ecclesiastical doctrine, with the sole object of multiplying and replenishing the earth with their kind.

Can we now draw any sociological analogy? Possibly, but not a too close analogy. Our social parasites do reproduce their kind, but not prodigally. Nevertheless, it is still true that the fat and easy life of the parasite more or less automatically leads to emphasis on sex. The struggle for existence on the part of the worker is still a form of sublimation of the sex instinct, not too complete, but nevertheless a compelled consideration of many things other than sex, many of which considerations do not trouble the parasite.

Looking further into the interesting aspects of parasitism, we may speculate a bit on the effects of parasitism in evolution. Parasites in general exert an injurious, but rarely a deadly, effect on their hosts, and host animals react by a defense mechanism or establish a tolerance for their parasites. In the long course of evolution the interaction of these parasites and host effects must surely have brought about profound changes in both parasites and hosts.

That animals once non-parasitic have taken up the easy life of parasitism, with the resulting degeneration and simplification of certain structures, such as some of the specialized sense organs, and with the resulting excessive development of the sex organs, is obvious enough. Entire groups, such as the tapeworms and flukes, have become so modified by parasitism that speculation as to their ancestral relationships with any existing nonparasitic groups has led to no generally accepted theories. Innumerable nematodes have abandoned the life of their free-living relatives in soil or water and gone the easier way of parasitism. In so doing they have undergone profound increases in size. Fattening at the expense of their hosts, there are but few, if any, of them that have not outstripped their free-living relatives which are usually not over a millimeter long. The giant of the parasite group, the dog kidney worm, is a yard long and as thick as one's finger, or 900 times as long as its probable nematode ancestor, and

many thousands of times as bulky. Thus we see how the parasite waxes fat.

Parasites wax fat at the expense of host animals that grow thin. For parasites affect their host animals unfavorably, and the commonest effect produced is what we broadly term unthriftiness. Now unthriftiness involves malnutrition, stunting and diminished growth. This effect of parasitism is most marked in young animals. Stunting through the growth period of youth leaves a permanent effect, since mature animals can not make up for failure to grow when young. The damage wrought by parasite toxins probably involves the endocrine system, and all this results in subnormal animals. This parasitism is ubiquitous, present in most animals in almost all places and at almost all times. The parasitized animals in subnormal condition do not produce as good stock as they might have produced otherwise. It calls for no great stretch of the imagination to visualize parasitism as one of the dwarfing factors that have held animals to their present size, and to conceive that without the development of this fatal and fascinating habit of parasitism the elephant to-day might be a better elephant and the mouse a bigger mouse. Civilized man is growing taller, possibly in part because civilization sets up insuperable barriers against most of man's parasites.

Parasites grow fat at the expense of host animals that grow thin. Is this true in sociology as in zoology? Has it a bearing on poverty, unemployment, hard times and other economic ills? Does food come to the tables of lifelong idlers by magic or by parasitism? Do millions go hungry because there is too much wheat, or in rags because there is too much cotton, or are these host animals clinical cases of social parasitism? Sociologists, economists or the reader may answer the questions.

Meanwhile, what defenses have host animals developed against their parasites? For one thing they have developed a tolerance for them, the ability to survive, as a rule, even with the double burden of feeding themselves and a horde of worms that not only feeds off them but in other ways injures and insults them. There is good reason to suppose that the large size of the liver in many vertebrates might be in part a response to parasitism. In some animals two thirds of the liver may be destroyed without visible bad effects on the animal. This suggests a large margin of safety in nature's specifications for livers, and may be correlated with the fact that poisons and parasites leaving the digestive tract by the portal system of the blood stream encounter first of all the efficient filter of the liver and work here their first, and sometimes their only, damage. Here many chemicals work their injury, and here many parasites are entrapped or destroyed. It seems highly probable that our oversize livers are in part a defense mechanism against parasitism.

The human hosts of social parasites have also their defense mechanisms. They too have developed tolerance and capacity for insult and injury. They too have the ability to support themselves and their parasite burden, and survive. Survive? Nay, verily, to enjoy and approve.

We may view parasitism, as many have viewed it, as an escape from the struggle for existence. But if we have represented the tapeworm as an object of scorn because of its parasitic habit, we have been misrepresenting the case and we have not been facing the facts. Some one, probably Karl Marx, a person looked on with disfavor in the best social circles, once stated that every one is either a worker, a beggar or a thief. He might have put the matter less baldly and more charitably by speaking of workers, scavengers, parasites and predators. Put even in that rather bald and blunt fashion, one would feel inclined to be a worker. But put with just a bit

more delicacy and finesse, put, for instance, in the form of an offer of a substantial assured income for life, with no further need for work, the vast majority of us would unhesitatingly elect the life free from care and worry—and work.

In other words we are fascinated with the life of parasitism, and, given the opportunity, we would choose parasitism. Perhaps this is the wise and philosophical thing to do. Perhaps the best of all possible goals of endeavor is a world without work. High authorities of various sorts have spoken with approval of the cultural value of unbroken leisure, of the happiness of the South Sea Islander, who does not exert himself beyond the exertion of eating, and of the beauty of rest and meditation without regard for the hurry and hustle of the world.

It seems as though the defeatist program of the parasite was our ideal and the preferred solution of the business of living for most of us. To secure a favorable balance of intake over expenditure we grasp the soft and easy solution of parasitism, with the parasite's minimum expenditures and with a host's contribution to intake. Psychologically, life has us beaten. Only the energy of a Roosevelt will develop a Rooseveltian eagerness for "the strenuous life." Under the lash of necessity we will work, and if we must work we may even find work a pleasure, but let an avenue of escape open up through which we may flee from labor to ease, from hard uncertainty to soft certainty, and we hasten to take on the comfortable life of the parasite.

Man begins his life as a parasite of the maternal body, and his first reaction to the free life is a wail of protest. From the child's desire for the wishing ring or Aladdin's lamp to the adult's hope of inheritance or of quick wealth in a gamble or speculation, parasitism is the heart's desire of man. Even in death he has the expectation of heavens of idleness tempered to the Christian by music and to the Mohammedan by houris. The successful parasite may expect congratulations and envy—not condemnation. His success will mark him as foresighted, or fortunate or sagacious. He may or may not be a mere, flaccid human tapeworm, but if he is he will be termed a gentleman of leisure.

It is true that one finds here and there rare and peculiar individuals who are scornful of parasitism, who abhor and even reject the secure and sheltered life when it is offered them, but it is probable that these few odd characters present physiological and mental peculiarities. They may feed on such food as other mortals, but their intake seems to be rather efficiently utilized to develop physical energy sufficient to meet life whether it come with a job or a fight, to develop mental energy sufficient to deal with life as a perplexity and an uncertainty, and to go unshaken through the disillusionment of life, to outgrow the love of toys and trinkets, the love of wealth and ease, and the love of fame, applause and approval, to find life interesting when faith and proven certainty alike prove unattainable, and to walk with a high head towards man's unavoidable destiny in death.

One is tempted to toy with the idea that the breeding of persons of this sort might be encouraged, with the idea that perhaps they could in some way be used in larger numbers. At first blush they would seem to be the ideal workers, but actually they do not fit into any category to the world's satisfaction. The worker in general, manual or intellectual, subscribes to our generally accepted doctrine of parasitism as an ideal. So long as he must be a worker he will serve as host to innumerable parasites, always with the understanding that in a country of opportunity for all he is permitted at the first opportunity to exchange his rôle of host for the rôle of parasite. Such workers are the dependable sup-

port of a society that glorifies parasitism. But these odd persons who reject the philosophy of parasitism will not serve willingly as hosts, nor live happily as parasites, nor sustain and subscribe to our philosophy of parasitism as the highest good. In a world which envisages an eternity of heaven as endless rest from toil and labor and trouble, these odd persons with their fondness for physical and mental activities, their desire to apply to every one the scriptural injunction to eat one's bread in the sweat of one's brow, their eagerness to grapple with life and its problems, are out of place. To adopt their philosophy on a large scale would be to overthrow much of our social structure, and the man who is opposed to social parasitism must be frowned upon as dangerous, for the state, the church, business and society believe in parasitism as the ideal of this life and the next.

Is this unkind or unfair? I think not. In a world in which parasitism, under more euphonious names, is so highly regarded as a form of freedom from the uncertainty and complexity of life, a world which pessimists critically regard with jaundiced eye as probably the best of all possible worlds, a world which both church and state to-day are more prone to view with alarm than to point to with pride, it has been said that one may elect to be the horse or the rider. One loses in public esteem and gains little in one's own self-esteem by electing to be the horse.

In spite of all this, some will agree with Wheeler that biology teaches us this categorical imperative: Do not be a parasite or a host, and try to dissuade others from being parasites or hosts. It may be—we shall not be here, so it will not matter to us—that some day social parasitism, life at the expense of others, may come into disfavor. We trust that in that event we shall have a safe and smooth adjustment to the now alien idea that all persons, meaning by that, all, should justify their existence by an adequate return to society for their share of society's contribution to them, and that there will be no occasion for the use of drastic and dangerous anthelmintics and insecticides in the treatment of present-day social parasitism. Before that day the economist and sociologist have a long educational program ahead of them if they are to persuade the man on the street that the legal exchange of money for the necessities and luxuries of life is not necessarily the giving of a *quid pro quo* for our living.

When, and if, that time comes, society may elect to apply the surgeon's scalpel to its hydatids, to take such drugs as will remove its tapeworms, to comb the lice from its hair, and to oil the ponds where its mosquitoes breed. Let us pray that the parasitologist who prescribes control measures for social parasitism may be sagacious. Zoologically, a world without its animal parasites would be a very different world from the world of to-day. Sociologically, a society without its human parasites would be a very different society from the society of to-day. Whether a world or a society without parasites would be a better world or society is another question. Intellectuals who believe that culture can grow only on a soil tilled by helots will elect a parasitized society, with themselves as parasites. Religionists who believe that society should attend to their physical needs while they devote their lives to the saving of their meager souls will elect a parasitized society. The idle inheritors of wealth will elect a parasitized society. Politicians who serve themselves and their friends from the cafeterias of national, state or city funds will elect a parasitized society. These groups will seek in the name of art to save the ticks for their gay colors, in the name of culture to save the fleas

for their ingenuity, in the name of religion to save the tapeworms for their tranquility, and in the name of humanity to save the mosquitoes that have come up from the dismal swamps to the glory of flight on gossamer wings.

All these may be right. In any case, let us look the facts in the face: We love and adore parasitism. We must admit it. Shall we continue our adoration? Will it lead us to our heart's desire of a world without work, or will it fasten on this man the inescapable rôle of parasite and on that man the unavoidable rôle of host? Will it ultimately destroy us in some future when a too heavy burden of parasites kills their hosts and a lack of hosts leaves the parasites to perish? Or shall we confront this adoration of parasitism and declare it outmoded? Shall we face the fact that life is and will long be a struggle for existence, that the longing for escape from that struggle is the stigma of the physical and mental weakling, and that the free man can not live the life of parasite or host? Shall we vote that in the incessant fight of man against nature's inexhaustible armament of weapons of frost and fire, of flood and famine, of pain and suffering, of disease and death, all men must bring to that fight an energy unweakened by the soft life of the parasite or by the sapped vitality of a host?

At this point we would bring out one important difference between animal parasitism and social parasitism. Although innumerable species of all sorts of animals have given up the free life for the life of parasitism, apparently no obligatory parasite has ever given up the parasite's life for the free life. It seems impossible for the true parasite to beat back to the free life or to retrace the steps of its degradation.

The case is not so bad for the human parasite. History and literature present many cases of the pathos and tragedy of the human parasites that have been ousted from their parasitic environment. Too often these unhappy mortals, fallen from their high estate as parasites, have been able to find for themselves only a scavenger's lot as beggar, beachcomber or hanger-on, tragic or pathetic figures of broken men and women, as incapable of dealing with life as is a tapeworm removed from its host. But in even more cases the human parasite has shown the extraordinary capacity for adaptation which has characterized this human animal that wanders from the tropics to the poles, that beats a path from the ocean to the mountain peaks, that stops at no barriers of height or depth, of fire or water. Unique in these respects, he is also unique in the ability of the human parasite to fall from a feather-lined nest, land on his feet, and start in pursuit of such grasshoppers, worms, suckers or berries as may come to hand or be sought for as desirable in lieu of his lost sustenance. This is a hopeful feature of the problem of social parasitism. The human parasite remains a facultative parasite. Given a generation of propaganda and the education of the young along selected lines, even his innate desire for parasitism may be definitely submerged under a substituted set of other desires, possibly even a desire for work.

INSECTS IN ENGLISH POETRY

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Bugs in Books

The Land of Literature constantly allures. I slip away from the irksome tasks of a prosaic world to make little excursions into its inviting borders. Sometimes the road irresistibly beckons, and I go on and on for a long time playing truant from duty. Again, the wanderlust seizes me in all its power, I cast everything aside, and go on prolonged journeys into the interior of this fascinating country.

For many years I abandoned myself to the delights of the journey, keeping no diary and collecting no souvenirs. I was content to luxuriate in memories ever blowing from those enchanted shores, as breezes refreshing the sultry air of a monotonous day and enhancing the atmosphere of a glamorous night. Then fellow travelers interested me in their mementoes. Many had become connoisseurs, some having acquired a galaxy of favorite portraits, others of landscapes, from the great galleries of literature. Many had made notable collections of birds or beasts or flowers. Finally, I, too, became imbued with the spirit of the collector. But what should I collect? The most widely known regions in the Land of Literature had been exploited by many travelers, some of them in a spirit of vandalism overrunning even the private domains of the most famous. Again I inspected the collections of travelers and to my surprise found but few specimens of insects. Surely these little creatures, so numerous in our own country, abound in the Land of Literature. Immediately I decided to go in search of them.

I equipped myself with all the paraphernalia of the entomologist.

As a miniature collecting kit I purchased a little notebook. For nets I secured many kinds of concordances. Some of these nets were of such coarse mesh that they would contain only the larger insects, allowing the smaller to slip through unnoted. Others were of fine, closely woven fabric, but the entrapped insects cleverly camouflaged themselves under pseudonyms and were thrown out as worthless.

My field glasses were powerful books of quotations. Standing upon some vantage ground, I could look through these glasses and sight the insects hovering over great stretches of territory. When the insects observed especially interested me, I would travel far to hear the cicadas sing from inviting nooks in Theocritus' verdant pastures or to watch the bees swarm among Emily Dickinson's thick hives.

It was with a feeling of trepidation that I completed arrangements for my undertaking. The evolution of the usual entomologist from a conspicuously bespectacled, absentminded bug chaser into a dignified scientist commanding both the respect and the coin of the realm has long been a notable example of complete metamorphosis. Not so with the literary entomologist. Requests for assistance for my enterprise were usually answered by a doubtful shake of the professorial head or ill-concealed ridicule from my fellows. Now, explorers who have traveled into the deepest recesses of literary jungles in search of birds and beasts have not only escaped all storms of derision but have been lauded as sportsmen. But to go ogling about for bugs in books! The guilty one must be a veritable book-

worm, some inferior species of the *Psocidae*. But who does not cherish the spirit of the pioneer. With an unshaken faith I sailed out over tractless seas. Rich treasures have been my reward.

In planning my explorations into the Land of English Poetry, I mapped out a tour that would carry me to old taverns enshrouded in a mist of tradition, to the radiant courts of the Renaissance, and to the flourishing soils of newly chartered fields. Into a tour of brief duration I crowded an itinerary including excursions to vast estates belonging to those long since crowned with fame and also to the fields of new settlers still breaking soil. On some of these excursions I carried great nets and field glasses, on others I took only a little collecting kit into which I dropped choice specimens.

The common belief that one finds what he is looking for proved true in my case. I was looking for insects on all my travels and to me they were the most conspicuous and important objects on the landscape. In a very literal sense I would "strain at a gnat and swallow a camel."[1] I imbibed something of the spirit of Conrad's Bavarian who, in an absorbing narrative of his capture of a gorgeous butterfly, referred to a murder he was forced to commit as a mere incident and to the capture of his insect as the all-important event of the day. I would travel down long roads of tragedy, and if no insect crawled across my path, I would return with a sense of futility, with nothing of that buoyancy of spirit that is supposed to follow the Aristotelian prescription for jaded spirits. Again, I would go sailing across seas of mirth, but when I landed, unless insects had fluttered around the boat, I cried out with the psalmist, "All is vanity!" But if insects were there! Ah, that was a different story. I returned with the air of a conqueror bringing in the rich spoils of victory.

Whether snatching at an occasional fly while journeying down the highway with Chaucer's pilgrims, or swinging a great net while treading Shakespeare's broad open fields or delving into the mysteries of the glades and forests of his vast estate; whether painfully caging the stinging insects that buzz in the torrid atmosphere of Pope's domain, or lazily coaxing the winged creatures that drift in the intoxicating sweetness of Shelley's garden—always I felt the pride of a connoisseur in my collection.

The poets were ideal hosts. In fair weather or foul, summer or winter, they escorted me down the long roads or the alluring byways of their estates to show me the objects of my search. Whether we chatted around the fireside in the blustery coldness of a winter night, or walked in the crisp freshness of a spring morning, or rested beneath the trees in the heat of a midsummer noontide, or strolled in the golden glow of an autumn twilight, my hosts obligingly discussed my favorite topic. Not only did they tell charming stories of the insects living among their own flowers but retold many fascinating tales of those belonging to bards of distant lands, far in time and space from their native shores.

I suffered the disillusionment common to all travelers. Sometimes in following bright insects down the pathways of gardens I had imagined wholly beautiful, I splashed into puddles of putrid, stagnant water. Sometimes, in chasing a rare insect through labyrinths of dense, tropical beauty I would stumble unawares upon decaying offal. But for the disappointing discovery that perhaps the loveliest gardens and the most beautiful estates always have little rubbish heaps, I was compensated many times over by the unexpected delights of every excursion.

As a traveler returning from a far country, I have brought these souvenirs.

[1] Matthew, 23: 24.

They are not intended to replace a visit but merely to encourage you to explore for yourself the marvels and beauties of the varied insect regions in the Land of Literature. The butterfly fluttering in the narrow confines of my insectary can but suggest the beauty of the butterfly flitting unhampered against a background of rainbow-hued flowers in Keats' garden. The beetles, stilted and cold in my exhibition cases, arranged as they are by the crude hand of a novice, can but poorly hint at the fascination of the flashing creatures that dance and glimmer in the sunlight among Francis Thompson's exotic bowers.

Some insects the poets have segregated and nourished from the rich nectar of a favorite flower of thought until they have developed into creatures of surpassing beauty. These I have seldom taken from the poet but have chosen instead specimens from more numerous varieties that sipped the nectar of many flowers and often were all but hidden in a profusion of blossoms. The specimens I shall show you were not selected as being typical or representative of any locality. From a poet who had many, I sometimes chose few, and *vice versa*. I wish only to give you some idea of the great variety of insects and their amazing adaptability to any environment in the infinitely varied regions of the great Land of Literature.

Metamorphosis

In the childhood of the race the bug was among those half real, half imaginary terrors that freighted man's waking moments with a sense of excitement and apprehension and startled him from slumber with a cry of fright.

Right as the humor of melancholye
Causith many a man in slepe to crye,
For fere of beris (bears) ore of bolis (bulls) blake,
Or ellis that blacke buggys wol him take.
—*Chaucer, "Nun's Priest's Tale," 1, 116.*

So persistent was the association of bugs with hobgoblins and specters that bugbear has become synonymous with anything causing terror. Because of the imaginary character of the associated evils, the term is particularly applicable to those things causing needless fright.

As the race has become more sophisticated, superstitious fear of bugs has vanished along with the dread of ghosts and specters. However, the scientist, who is chiefly responsible for banishing specters of all kinds, has brought little relief from the terror of the bug. With all the miraculous instruments of modern invention at his command, he has with a seeming wizardry cleared the air of superstition. Yet he has replaced an imaginary fear by a scientific reality. Primitive man could cherish the hope that bugs might not be so terrible as he feared. Any faint hope of modern man that his fears may be groundless is shattered by a battering ram of incontrovertible facts bolstered up by profound theories.

Bugs with their aura of spooky associations flourished in the time of fairies and elves. This season past, they wound themselves into cocoons and went to sleep. When they emerged in the springtime of scientific investigation, behold, they were more terrible than before. Viewing them in the clear sunlight of fact, through eyes whose power of penetration is greatly manifolded, man need no longer have illusions about the bug. He has learned of a certainty of the unmistakable power of the bug which disappeared as a bogey to return as an actual and formidable enemy, reinforced with the means of destruction, all the more to be dreaded because his weapons dealing pestilence, disease and death are discernible only to the keen eye of the scientist as he searches them out with powerful lenses.

The scientist, speaking in a voice

ringing with the authority of the prophetic messages of old, warns of imminent danger from the enemy. The people rally to the defense. They continuously pour into the coffers of the nations of the world a great stream of gold. More and more of them enlist as new recruits in that great army of soldiers who go out to fight in the front line trenches. Yet all their efforts have but temporarily checked the advancing forces. The changing conditions of retreating mankind have but rendered more effective the weapons of the enemy. Not only has the enemy augmented his forces with an alarming arithmetical progression, but from each successive instar he has emerged more terrible than before. When his metamorphosis is complete, who can doubt that he will find a place in the epics of the future (if he does not completely annihilate mankind, as some with wavering confidence prophesy) comparable to that of the dragons and monsters in the epics of the past.

Plagues

It is only in the realm of childhood that the old shadowy, and perhaps instinctive, fear of bugs still persists. Spenser speaks of "bugs to fearen babes,"[2] and one of Eugene Field's little heroes boasts, "I ain't afraid uv snakes, or toads, or bugs, or worms or mice."[3] Dismissing a threat, Petruchio exclaims," Fear boys with bugs."[4]

The insect frequently, and fortunately, presents a less formidable aspect. He may take an elfish delight in annoying man, as the mosquito which disturbs his slumber, or the fly that returns with a devilish persistence to the most ticklish spot on a bald head. Across the pages of his famous diary, lice crawl dangerously near the crowned heads Pepys so closely and irreverently inspects. Presumptuous fleas divert his attention from the engrossing news of court scandal and bring down his wrath and his fists upon the careless maids who failed to search his bed carefully enough to insure his comfort. Though he displays an uncontrollable temper when fleas attack him, he hugely enjoys jesting with a companion of the night who was strangely singled out by the fleas for their exclusive attention.

> We lay very well, and merrily; in the morning, concluding him to be of the eldest blood and house of the Clerke's, because that all the fleas come up to him, and not to me.

To Aristophanes bedbugs were so pestiferous that the most felicitous abode his imagination could picture — in fact, heaven—was a place made up of "ports —streets, hotels, where bedbugs are most scarce."[5]

Though man may be feverishly excited while the victim of an annoying insect, his "emotion recollected in tranquillity" often finds an outlet in an amusing parody or jest. Thomas Hood evidently obtained enough pleasure from "The Cannibal Flea" to compensate him for a night's unrest.

> It was many and many a year ago,
> In a District styled E. C.,
> That a monster dwelt whom I came to know
> By the name of Cannibal Flea
> And the brute was possessed with no other thought
> Than to live—and to live on me.

Scogin perhaps felt that he was amply remunerated for any personal inconvenience by the money and the fun he obtained from selling the old wives a powder concocted from rotten wood, which he claimed, with all the seriousness of the modern salesman, was effective for killing fleas.[6] It may have been in the spirit of the wife of one of the

[2] Spenser, "The Faerie Queene," Canto 12, St. 25.

[3] Eugene Field, "Seein' Things."

[4] Shakespeare, "Taming of the Shrew," Act 1, Sc. 2.

[5] Aristophanes, "The Frogs."

[6] Hazlitt, "Dictionary of Faiths and Folklore."

"American Men of Science," who permitted a conjurer to attempt the removal of her warts, or it may have been in a fog of superstition that the people of the Middle Ages employed the following remedy for ridding themselves of fleas.[6]

A very easie and merry conceit to keep off fleas from your beds or chambers. Plinie reporteth that if, when you first hear the cuckow, you mark well where your right foot standeth, and take up that earth, the fleas will by no means breed either in your house or chamber, where any of the same earth is thrown or scattered.

From remote antiquity man has regarded the insect as a means of torture to effect retribution in the erring individual or nation. The disobedient Jonah was denied the comfort of his gourd vine, for "God prepared a worm when the morning rose the next day, and it smote the gourd that it withered."[7] Keats, at least in this instance showing symptoms of some of the evils he sets out to correct in others, prescribes the terrible sting of the gadfly as an effective punishment for nearly all misdemeanors.[8]

While it is not known of a certainty whether the worms causing the loathsome diseases of the sufferers in some of the old chronicles were Nematelminthes or the larvae of insects, scientists agree that the accounts might with accuracy refer to the larvae of certain insects. In his story of the wrath of God against a wicked man, a monk says:

The wreche of God hym smoot so cruelly,
That thurgh his body wikked wormes crepte,
And ther-with-al he stank so horriblely
That noon of al his meynee that hym kepte,
Wheither so he a-wood or ellis slepte,
Ne myghte noght for stynk of hym endure.
—*Chaucer, "The Monk's Tale."*

In a mood of dejection because he feels that life hangs by such a slender thread, Boethius asks:

For yif thou loke wel up-on the body of a wight, what thing shault thou finde more freele than is mankinde; the whiche men wel ofte ben sleyn with bytinge of smale flyes, or elles with the entringe of creepinge wormes into the privetees of mannes body.
Chaucer, "Boethius," Bk. 11, p. 6.

Job, in that mighty drama of the whole problem of human suffering, cries out in anguish from his ash heap.

My flesh is clothed with worms and clods of dust; my skin is broken, and become loathsome.
—*Job, 7: 5.*

Insects have changed the course of human history. Lice and flies sent as plagues to effect the liberation of the Jews softened the heart of a stern monarch whom the wailings and pleadings of an entire people had left hard and obdurate. Before Pharoah would relent

Frogs, lice, and flies must all his palace fill
With loathed intrustion, and fill all the land.
—*Milton, "Paradise Lost," 12: 177.*

Moses must have been acting under the guidance of a friendly providence when he chose as plagues for his oppressors the insects most loathsome to them. To the Egyptians, who took meticulous care of their bodies, the infestation of lice was especially abhorrent. They regarded lice not only as an outrage against bodily cleanliness but as a profanation of the temple if they entered to worship while harboring such vermin. Both the personal habits and the clothing of the priests were regulated by their fervent desire to keep free from lice. "The judgments, therefore, inflicted by the hand of Moses were adapted to their prejudices. It was, consequently, not only most noisome to the people in general, but was no[9] small odium to the most sacred order in Egypt, that they were overrun with these filthy and detestable vermin."

[7] Jonah, 4: 7.
[8] Keats, "The Gadfly."
[9] Harris, "Natural History of the Bible."

Insects have a prominent place in Solomon's catalog of the worst calamities that can afflict a nation.

> If there be in the land famine, if there be pestilence, blasting, mildew, locust, or if there be caterpillar; if their enemy besiege them in the land of their cities; whatsoever plague, whatsoever sickness there be.
>
> —*1 Kings, 8: 37.*

In Joel's picture of complete destruction and utter desolation, insects assume a terrible importance.

> That which the palmerworm hath left hath the locust eaten; and that which the locust hath left hath the cankerworm eaten; and that which the cankerworm hath left hath the caterpiller eaten.
>
> —*Joel, 1: 4.*

Commentators in general agree that translators have been vague and indefinite in their interpretation of the names of insects in the Bible. There is not always conclusive evidence as to the specific insect intended. Whatever the insect, the effectiveness of the punishment it inflicted is attested by the results obtained.

When directed against foes, plagues are designated as punishments wisely inflicted by a helpful providence. When the situation is reversed and plagues afflict the "chosen" people, they are decried as the unmerited visitation of Satan.

The cricket, descending upon the fields of the pioneer Mormons in such distressing numbers that it withstood both their "faith and works,"[10] is described as having an appearance that "suggests the idea that it may be the habitation of a vindictive little demon." Reserve food supplies had been greatly depleted by a new influx of disciples, and existence itself depended upon the increase of the fields. When the unavailing prayers and ineffectual attempts to vanquish their foes had left the pioneers desperate, great flocks of gulls alighted, driving them into a panicky fear of starvation. They visualized the desolation pictured by Joel when one pest consumed what the other left. Imagine their rejoicing when they discovered that the gulls were not eating the remnants of their crops but were devouring the crickets instead.

The coming of the gulls was interpreted as divine intervention, a miracle, which, though belated, prevented starvation. The gull immediately became a sacred object, protected by legislation, eulogized in song and story, and commemorated in the "Sea-gull Monument." Every means of extolling the gull necessarily includes the cricket. Thus, the insect becomes important in the literature of the people, whether it be hailed as a deliverer or condemned as a pest.

Events of such cataclysmic proportions as plagues recur inevitably in the literature of the people. Already such narratives of the period as Rolvaag's "Giants in the Earth" contain vivid stories of the Rocky Mountain locusts that descended as a great, devastating cloud upon the fertile plains of the pioneers and arose leaving only barren ground. When this catastrophe recedes farther into the realm of the past, it doubtless will take an increasingly important place in the traditionary lore of the country.

Though insects have caused many epidemics of national importance, they frequently have been wholly absent from the literature arising out of the calamity. Sometimes it is not until decades afterward that science discovers the fact that insects spread the epidemic. Had the people of the Middle Ages known that the bite of the flea was responsible for the horrors of the bubonic plague, they probably would have entertained superstitions quite different

[10] Professor Kimball Young, "A Story of the Rise of a Social Taboo," SCIENTIFIC MONTHLY, May, 1928.

from their half-mirthful ideas of this parasite.

When the insect temporarily or permanently thwarts man's most colossal undertakings, he consequently becomes the motivating force back of an interesting literature. The mosquito vehemently slew an enormous army of workers, rendered idle and useless the most ingenious machinery of the world, and thereby balked a nation's plans to construct the Panama Canal. A great army of skilled engineers went out equipped to conquer the Andes and build a railroad into the clouds. However, they soon found that their most formidable foe was not the forbidding mountains armed with gigantic swords of ice, but the mosquitoes that ruthlessly condemned them to death or subjected them to long years of the tortuous dengue fever. The mosquito, a villain of such magnitude that he exacts admiration for his tremendous power, becomes comparable to Satan, who in the enormous scope of his majestic evils in "Paradise Lost" usurps the place of the hero.

When man does not respond to the retributive influence of the scourge of the gods, he is consigned to a hell where his tormentors pursue him to vent upon him their eternal torture. The dreaded gadfly is ordered,

> . . . get thee back to hell—
> To sting the ghosts of Babylonian kings.
> —*Shelley, "Oedipus Tyrannus."*

What more excruciating punishment could be devised than

> . . . a red gulf of everlasting fire,
> Where poisonous and undying worms prolong
> Eternal misery to those hapless slaves."
> —*Shelley, "Queen Mab," IV.*

Supernatural beings are not immune to the scourge of insects. The goddess, Io, transformed into a white heifer, was doomed to undergo the harrowing torment of the gadfly.

> The Gadfly was the same which Juno sent
> To agitate Io, and which Ezekiel mentions
> That the Lord whistled for out of the mountains
> Of utmost Aethiopia, to torment
> Mesopotamian Babylon. The beast
> Has a loud trumpet like the scarabee,
> His crooked tail is barbed with many stings,
> Each able to make a thousand wounds, and each
> Immedicable; from his convex eyes
> He sees fair things in many hideous shapes,
> And trumpets all his falsehood to the world.
> —*Shelley, "Oedipus Tyrannus."*

Minuteness

Though man quail in terror and helplessness before multitudes of insects, he reverses his attitude in the presence of small numbers of them, frequently scorning them as insignificant. They become for him an effective source of belittling epithets. In rapid succession insects flew from the fiery tongue of the infuriated Kate when she screamed to her unwelcome suitor, "Thou flea, thou nit, thou winter-cricket thou!"[11] Along with the household bric-a-brac the cognomen "insect" descends with an amazing frequency upon the head of Jiggs of comic strip fame. Mutt not only hurls bottles and bricks at the vanquished Jeff but adds verbal bugs to his flying missiles.

Because of its small size, the poet finds in the insect an impressive means of describing things rendered small by distance or unimportant by comparison with things of greater value. Ants are often chosen when great numbers are involved.

> The thronging thousands, to a passing view,
> Seemed like an ant-hill's citizens.
> —*Shelley, "Queen Mab," II, 101.*

In veneration of the Lord, the prophet Isaiah says, "It is he that sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers." In his "Hymn to Apollo," Keats in abnegation questions,

[11] Shakespeare, "The Taming of the Shrew," Act IV, Sc. 3.

O why didst thou pity, and for a worm
Why touch thy soft lute
Till the thunder was mute?

Realizing his helplessness, but resenting his oppressor, the poet protests:

No more, thou thunder-master, show
Thy spite on mortal flies:
—*Shakespeare, "Cymbeline," Act V, Sc. 5.*

When so unimportant as to pass unobserved, man often compares himself to an insect. "I was no more noticeable than an insect."[12]

Then of the crowd ye took no more account
Than of the myriad cricket of the mead.
—*Tennyson, "Lancelot and Elaine."*

The insect appeals to Chaucer most as an expression of insignificance. His little nun says of an unsavory story, "Swich talkyng is nat worth a boterflye." Those who resent the fact that Chaucer calls such a beautiful insect as a butterfly worthless may be appeased when they remember that he also classified the hen, that to-day universally lays golden eggs, as "worthless."

An old book of astrology, an adversary, a charm, the noise of "The Parlement of Foules," are all characterized as "nat worth a flye." The general worthlessness of flies appears in Scotch dialect when Burns writes, "Gang by me as tho' that ye car'd nae a flie," when his Philly says to her poor Willy, "I care nae wealth a single flie," and when his "Country Lassie" sings,

For Johnnie o' the Buskie Glen,
I dinna care a single flie;

The immense diversity of the literary application of the idea of the insignificance of insects may be illustrated in the following quotations which with a striking appropriateness involve the little sonnet and immeasurable eternity.

Tut, tut, your sonnet's a flying ant,
Wing'd for a moment.
—*Tennyson, "Queen Mary," 11: 2.*

[12] Conrad, "Lord Jim."

Then conquered, thou, eternity, shall lie
Under my hand as little as a fly.
—*James Stephens, "The Lonely God."*

Minute size is not always correlated with insignificance. Little insects swiftly fly to thoughts of dainty, fairy-like things. Only in the silence of seclusion, can the ear hear such sounds as

Seeds in a dry pod, tick, tick, tick,
Tick, tick, tick, like mites in a quarrel.
—*E. L. Masters, "Petit, the Poet."*

Only in the motionlessness of an atmosphere where all things but thought are chained to earth can the imagination hear such music as Hamlet heard when

He sat so still, his very thoughts took wing,
And, lightest Ariels, the stillness haunted
With midge-like measures;
—*De La Mare, "Hamlet."*

An extremely little book of postage-stamp proportions has pages described as

. . . every marge enclosing in the midst
A square of text that looks a little blot,
The text no larger than the limbs of fleas;
—*Tennyson, "Merlin and Vivien."*

What a diminutive little creature to have eyelashes "Not longer than the May-fly's small fanhorns,"[13] or to be clothed as "Wee Willie Gray."

Wee Willie Gray, and his leather wallet,
Twice a lilie flower will be him sark and cravat.
Feathers of a flie wad feather up his bonnet,
Feathers of a flie wad feather up his bonnet.
—*Burns, "Wee Willie Gray."*

Easily does the insect drift into fairyland where he is at home with fairies and elves and gnomes. A cricket is sent on the mission of a mischievous elf to pinch the slatternly "maids as blue as bilberry." Fairies, "Thieves of a guise remotely fair," sneak into the hive and rob the bees of their honey.[14] Titania,

[13] Keats, "Oh, I am frightened."
[14] De La Mare, "The Honey Robbers."

in the fascinating delusion of a "Midsummer Night's Dream," commands the fairies that they

The honey bags steal from the humble-bees,
And, for night-tapers, crop their waxen thighs,
And light them at the fiery glow-worm's eyes,
To have my love to bed and to arise;
And pluck the wings from painted butterflies,
To fan the moonbeams from his sleeping eyes;

No more fitting equipage for the queen of the fairies could be devised than that having

... waggon-spokes made of long spinners' legs;
The cover, of the wings of grasshoppers;
The traces, of the smallest spider's web;
The collars, of the moonshine's watery beams;
Her waggoner, a small gray-coated gnat,

. . . .

Her chariot is an empty hazel nut,
Made by the joiner squirrel or old grub,
Time out o' mind the fairies' coachmakers.
—*Shakespeare, "Romeo and Juliet," Act. 1, Sc. 4.*

The gnat as a waggoner and the grub as a coachmaker become admirable servitors of the fairies, but too seldom do the captivating lovers, for whom even the flowers languish, enter the realm of fairyland to become equals of the fairies. The emperor moth in the richness of his royal robes might arouse the envy of the fairy king; the ethereal Chrysopid with gossamer dress of delicate green and headdress of gleaming gold might rival the beauty of the fairy queen. The grotesque little leaf hoppers would delight the elves as playmates.

Naïve delight in fairies and elves is changed in a sophisticated age to an equal delight in the natural marvels of their prototypes, the insects.

Ye lovers of marvel and fairy lore,
Say not that the days of enchantment are o'er,

. . . .

There are streamlets yet where the river-sprite
With his Harlequin changes bewilders the sight;
There are castles yet of ivory and gold,
Hung with floral fabrics by sunshine unroll'd,
Within whose luxurious recesses recline
Fays of exquisite form, quaffing exquisite wine;
Some in gossamer veiled or ethereal dyes,
Which have only their match in the rainbow'd skies;
Some in richest and softest of velvets arrayed,
Or in mail that does shame to the armourer's trade.
These are haunting us ever for ill, or for good,
Through earth and through air, field, forest, and flood;
To transport our thoughts, as by magic spell,
From the sordid objects whereon they dwell,
To a land of the Marvellous dimly displayed,
Where light-winged Fancy, by wonder stayed,
Still delighteth to hover, and joyously say:
'Oh! my darling elves, ye're not chased away,
There's a region still where ye have a place—
The myterious world of the Insect race.'
—*Acheta Domestica, "The Moth Book—Holland."*

Color

In the distant past only the insect could supply that most adored color of the ancients—the beautiful scarlet which brightened the tapestries of Egyptian temples, adorned Phoenician beauties, and became the insignia of royalty denied to those of lowly birth. Though the chemist has long since surpassed the insect in his ability to transform drab cloth into fabrics glowing with color, he has never been able to rival the insect's own colors nor has the designer ever equalled the intricacy and beauty of his patterns. He obtains his most beautiful color effects when he abandons his own devices and faithfully attempts to reproduce the designs furnished by the insect. The butterfly costumes of the dazzlingly beautiful musical comedy, "Rio Rita," arouse the enthusiastic admiration of all who see them and commend the artistic taste of the designer who painstakingly followed the exquisite color patterns of the Papilionidae.

Of all the colorful insects that brighten his gardens and lawns, the poet shows the greatest fondness for those of golden hue. When he turns artist, he burnishes his canvas with the gold of grasshopper, beetle, butterfly

and bee. With discriminating eye and skilled hand he pictures

. . . the golden-cuirassed bee
. . . .
In the white lily's breezy tent.
—*James Russell Lowell, "To the Dandelion."*

Or enlarging the canvas, he shows a garden,

. . . fragrant everywhere;
In its lily-bugles the gold bee sups,
And butterflies flutter on winglets fair
Round the tremulous buttercups.
—*Munkittrick.*

Against the sunshine of a summer day, he paints a "Beetle panoplied in gems and gold,"[15] or a "gilded"[16] butterfly. In the eventide he shows in quiet, sweet beauty

All the woods hushed—save for a dripping rose,
All the woods dim—save where a glow-worm glows.
—*Masefield, "The Watch in the Wood."*

Or with a few delicate strokes he depicts the soft radiance of the light of a

. . . glow-worm golden
In a dell of dew,
Scattering unbeholden
Its aereal hue
Among the flowers and grass which screen it from view.
—*Shelley, "To a Skylark."*

The poet constantly delights in the "circles of green radiance"[17] shed by the soft light of the glow-worm or firefly. Against a dark background De La Mare draws an enchanting

. . . jasmine bower,
Lit pale with flies of fire.
—*"The Isle of Lone."*

and captures the allurement of a tropical night in his picture of

. . . the isles where the pink coral and palm branches blow,
And the fireflies turn night into day.
—*"Andy Battle."*

15 Wordsworth, "Indolence."
16 Shakespeare, "Coriolanus," 1: 3.
17 Wordsworth, "Evening Walk."

Although the poet favors golden insects, he reproduces butterflies of all colors of the rainbow. Upon his canvas he throws "crimson wings,"[18] "vans azure and green and gold,"[19] "purple plumes,"[20] the "wing'd violet,"[21] and and the "snow-white butterfly."[22]

Keats has recaptured the charm of an old mosaic in his

. . . casement high and triple arch'd—
All garlanded with carven imag'ries
Of fruits, and flowers, and bunches of knot-grass,
And diamonded with panes of quaint device,
Innumerable of stains and splendid dyes,
As are the tiger-moth's deep-damask'd wings;
—*Keats, "St. Agnes."*

With a kindred love for a medley of color, Ina Coolbrith paints

A jewelled moth; a butterfly, with rare
And tender tints upon his downy wing
. . . .
Its petal-wings of broidered gossamer
—winged bloom!—blossom-butterfly!
—*"Mariposa Lily."*

Insects of brilliant hue enhance the beauty of a sunny landscape, those of neutral shades accentuate the dismal tone of a gloomy scene. Such are the "many a brown and dusky wing" flitting across a "moonless dun"[23] and a "great white moth" fading "miserably past."[24]

The poet seldoms introduces into his pictures of the unlovely any but insects of nondescript color. However, the colorful insects so numerous in cheerful scenes are caricatured by Montgomery as "insect legions, prank'd with gaudiest hues." Riley uncomplimentarily gives his butterflies "sallow-yellow" wings.

18 Wordworth, "The Redbreast Chasing the Butterfly."
19 Sir Edwin Arnold.
20 Haworth, "Holland-Butterfly Book."
21 Alfred Street.
22 R. H. Horne, "Genius."
23 Whittier.
24 Henley.

The insect may lend beauty to any landscape or exquisite charm to the portrait of "The Tired Cupid,"

> A shimmering moth its pinions furls,
> Grey in the moonshine of his curls.
> —*De La Mare.*

MOTION

Dancers

When the harmony of color and the poetry of motion unite in the graceful body of a colorful insect, the poet is entranced. What scintillating beauty in "the lightning flash of insect and of bird,"[25] in the dragonfly shooting by "like a flash of purple fire,"[26] in the sudden alighting of the "silken winged fly,"[27] in

> The beetle flashing in his minute mail
> Of green and golden scale;
> —*F. Thompson, "The 19th Century."*

The light of the firefly or glowworm, beautiful as it is in the stillness of a picture, is far more lovely in the changing radiance of the dance.

> Like winged stars the fire-flies flash and glance,
> —*Shelley, "Gisborne."*

or

> . . . flit, and swarm, and throng,
> Till all the mountain depths are spangled.
> —*Faust, 11.*

Living fireflies, enmeshed in gauze and worn as ornaments in the hair of natives of the Caribbean Islands, suggest that

> . . . the Pleiads, rising thro' the mellow shade,
> Glitter like a swarm of fireflies tangled in a silver braid.
> —*Tennyson, "Locksley Hall."*

A single glowworm "a moving radiance twinkles"[28] while many are "in the torch-dance circling."[29]

[25] Tennyson, "Enoch Arden."
[26] "The Lover's Tale."
[27] Shelley, "Witch."
[28] Thomson, "Summer."
[29] Heine, "Donna Clara."

As if to let the spectators drink in their beauty

> The gold-barr'd butterflies to and fro
> And over the waterside wander'd and rove,
> As heedless and idle as clouds that rove
> And drift by the peaks of perpetual snow.
> —*J. Miller, "Isles of Amazons."*

In the dance of most delicate grace Endymion, beloved of a goddess, becomes dancing partner to a "golden butterfly," which pauses to refresh itself at

> The crystal spout-head;—with touch
> Most delicate, as though afraid to smutch
> Even with mealy gold the water clear.
> —*Keats, "Endymion."*

A bee leads a boy a merry dance.

> . . . the June bee
> Before the school-boy
> Invites the race;
> Stoops to an easy clover—
> Dips—evades—teases—deploys;
> Then to the royal clouds
> Lifts his light pinnace.
> —*Emily Dickinson, XXIX.*

Pan lies prone with

> . . . his face in the dazzle and glare
> Of the glad sunshine; while everywhere,
> Over, across, and around him blew
> Filmy dragon-flies hither and there,
> And little white butterflies, two and two,
> In eddies of odorous air.
> —*James W. Riley.*

The most colorful insects charm the poet by the beauty of their solo dances. The minute insects of nondescript, drab color seldom attract his attention unless they appear in a chorus where they become the personification of rhythmical grace.

> . . . there is dancing in yonder green bower,
> A swarm of young midges, they dance high and low.
> —*Owen Meredith (Lord Lytton.)*

For Robert Tannahil "The Midges Dance Aboon the Burn" in a fascinating manner. Francis Thompson enjoys

watching the gnats as they "Maze, and vibrate, and tease the noontide hush."[30]

With a rare gift, the poet chooses backgrounds against which his insects can dance to best advantage. Whether he provides for them a stage emblazoned with all the theatrical devices for the spectacular or chooses instead a pastoral scene of simple charm, his performers dance with unsurpassed grace. Often the dance is interpretative rather than an interlude to interest the audience while the scenes are changing. Such is that of the

> . . . snow-white butterfly
> Dancing before the fitful gale
> Far out at sea.
> —*G. H. Horne, "Genius."*

Enchancing the weird atmosphere of "The Guerdon,"

> A dragon-fly in narrowing circles neared,
> And lit, secure, upon the dead man's beard,
> Then spread its iris vans in quick dismay,
> And into the blue summer sped away–
> —*Aldrich, "The Guerdon."*

The horror of "The Massacre" is epitomized in the insects that avoid the terrible scene.

> Never a whir of wing, no bee
> Stirred o'er the shameful slain;
> Nought but a thirsty wasp crept in,
> Stooped, and came out again.
> —*De La Mare.*

The repulsive finds a place on the poet's stage as effective as the gargoyles on the most beautiful cathedrals. Insects dance in such scenes as effectively as among the sweetest flowers.

> . . . a hut bestrewn with skulls of beeves,
> Round which the flies danced, where an Indian girl
> Bleared at him from her eyes' ophthalmic eaves.
> —*Masefield, "Daffodil Fields."*

Rivaling the beauty of the rapidly swirling dances are those motionless moments when the insect is poised, afloat as when

> Deep in the sun-searched growth the dragon-fly
> Hangs like a blue thread loosened from the sky;
> —*D. Rossetti, "Silent Noon."*

or when "Amid the lilies floats the moth";[31] or when

> . . . here and yonder a flaky butterfly
> Was doubting in the air.
> —*MacDonald.*

Acrobats

The insect acrobats of the air, performing daring feats, give an audience all the thrills of the sawdust ring. From a dizzy height the agile bee darts into a foxglove bell,[32] dives "into faint flowers," or "swings ower the white-clovery sod."[33] The show is over all too soon for Davies

> When butterflies will make side-leaps,
> As though escaped from Nature's hand
> Ere perfect quite; and bees will stand
> Upon their heads in fragrant deeps;
> —*"Days Too Short."*

The spectator watches with rapt attention when "bees abashless play,[34] when they wrestle with cowslips,[35] when they row all day "upon a raft of air,"[36] and when with military precision

> Baronial bees march, one by one,
> In murmuring platoon;
> —*E. Dickinson, LIX.*

With all the glamor of a medieval knight in combat, the bee bravely tilts away with many flowers.

> Like trains of cars on tracks of plush
> I hear the level bee;
> A jar across the flowers goes,
> Their velvet masonry.
>
> Withstands until the sweet assault
> Their chivalry consumes,

30 Francis Thompson, "Ode to the Setting Sun."

31 De La Mare, "Lullaby."
32 Wordsworth, "Borderers."
33 MacDonald.
34 E. Dickinson, CIV.
35 Keats, "Ep. to Brother."
36 E. Dickinson, CII.

While he, victorious, tilts away
To vanquish other blooms.

His feet are shod with gauze,
His helmet is of gold;
His breast, a single onyx
With chrysoprase, inlaid.
—*E. Dickinson, LXV.*

The daring feats of the insects are not always performed for their amusement, but sometimes become pressing necessities to evade the talons of a pursuing enemy. It is only by greater dexterity that the butterfly can escape the Redbreast,[37] an enemy of much greater size and strength. For the sport of Persian kings the butterflies were sacrificed in grim encounters with sparrows and starlings trained to capture them.[38] For the amusement of the populace, a cricket is sent out to meet in mortal combat another cricket armed with weapons as powerful as his own. The terrific struggle, which ends only when one of the contestants surrenders in death, holds the same fascination for the people of Japan as the cock fight for those of Mexico, or the bull fight for those of Spain.

Insects sometimes drown their troubles or celebrate their festivities in wine. Bees are not always the sober, industrious creatures they are reputed to be. The old adage of the straightness of the bee-line is completely reversed by the poet who has discovered that bees drink intemperately of the wine of many flowers. Would not the sages who have held up the bee as a pattern of exemplary conduct turn in their graves to see him reel "from bough to bough"?[39] sometimes getting so obstreperous that

. . . landlords turn the drunken bee
Out of the foxglove's door.
—*Emily Dickinson.*

Not only does the bee become "giddy with clover"[40] but drunk from the spicy wine of "carnations red." On the testimony of the poet the bee partakes intemperately of the wine of flowers; on the testimony of the distillers of the Blue Ridge Mountains, he imbibes too freely of the liquor of the corn. The distillers would be the last to criticize the morals of their customers, but they denounce the bee as an inveterate toper because, by his unseemly conduct, he inadvertently attracts the attention of revenue officers who follow his staggering path to their sheltered cove.[41] The poet now suspects that the bee is the reincarnated god of wine, Bacchus himself.

Listen to the tawny thief,
Hid beneath the waxen leaf,
Growling at his fairy host,
Bidding her with angry boast
Fill his cup with wine distilled
From the dew the dawn has spilled:
Stored away in golden casks
Is the precious draught he asks.

Who—who makes this micmic din
In this micmic meadow inn,
Wings in such a drowsy note,
Wears a golden-belted coat;
Loiters in the dainty room
Of this tavern of perfume;
Dares to linger at the cup
Till the yellow sun is up?

Bacchus 'tis, come back again
To the busy haunts of men;
Garlanded and gaily dressed,
Bands of gold about his breast;
Straying from his paradise,
Having pinions angel-wise,
'Tis the honey-bee, who goes
Reveling within a rose!
—*F. D. Sherman, "Bacchus."*

Bees are not the only inebriates of the insect world. Cicadas become "drunk with noonday dew"[42] and butterflies "go staggering"[43] through the air. Bees, in filching intoxicants,

[37] Wordsworth, "The Redbreast Chasing the Butterfly."
[38] Burton, "On Melancholy."
[39] Oscar Wilde, "Her Voice."
[40] Jean Ingelow.
[41] "Greenville News."
[42] Shelley, "The Witch of Atlass," VIII.
[43] W. H. Davies, "Light."

have but followed the example of flies that have always swarmed

. . . in vintage time,
About the wine-press where sweet must is poured,
—*Milton, "Paradise Regained," 4: 15.*

Though the bee win in acrobatic sports and though he pay deference to Bacchus, he does justify confidence in his industry. Gay, among a host of others, has seen him

With golden treasures load his little thighs,
And steer his distant journey through the skies,
—*Gay, "Rural Sports," Canto 1.*

The bee is not habitually a night club guest. At nightfall James Stephens often watches as

The bee
Speeds
Home!

Music

Whether the insect dance and play or work, he usually has a musical accompaniment for his activities. The efficiency expert, with the bombasity of a great discoverer, advocates music to increase the output of operatives in office, factory or mill. Long ago he might have learned from the example of the insect. However, man must overcome a difficulty which the insect has never had to surmount. He has the problem of timing the music to the actions of employees working at a different speed. The radio in the home is not always conducive to work, often becoming a distracting influence because of its erratic programs which may contain jazz tunes when slow painstaking work is attempted or a slow meditative melody when rapid work is undertaken. The music of the insect, on the other hand, is perfectly and inevitably synchronized with its movements. Flights of song and flights through the air are simultaneous, the rapidly vibrating wings accelerating the pace of the flyer and the tempo of the song or slowly waving wings retarding the rate of flight and prolonging the tones of the melody.

Many poets have gratified their curiosity by examining the insect's musical instruments. The ultra-modern Walt Whitman shares with the very ancient Meleager an interest in the mechanics of music. Whitman designates the wing of the katydid as a "chromatic reed."[44] Meleager pleads with the grasshopper: "—harp to me some tune of longing, striking thy vocal wings with thy dear feet." And he asks the cricket, that draws its leg like a violin bow over the chitinous wing surface, for music made "with serrated legs and swart skin."[45] Wordsworth explains that

The roving bee proclaims aloud
Her flight by vocal wings.
—*Wordsworth, "The Soaring."*

The human ear, as an imperfectly attuned radio, can receive but few of the insect melodies, and insect songs that to man seem only a monotone may be filled with lilting trills which fall unheeded on his coarse ears—ears which hear only the bass-drum notes of those high pitched melodies. How infinitely lovely must be the myriad unheard melodies of those aerial musicians whose very flight is song. What delicate overtures in that high treble when

The midge's wing beats to and fro
A thousand times ere one can utter 'O.'
—*Coventry Patmore, "The Cry at Midnight."*

Only the poetic mind that

. . . is ever startled by the leap
Of buds into ripe flowers; or by the flitting
Of divers moths, that aye their rest are quitting.
—*Keats, "I Stood Tiptoe upon a Little Hill."*

can faintly imagine the delicacy and grace of the musical accompaniment of

[44] Walt Whitman, "Song of Myself."
[45] MacKail, "Meleager, Greek Anthology."

the dance of the butterflies. Could the ecstatic notes of the song of the nuptial flight of the bees or the fireflies but reach the receptive ears of the poet, would he not be inspired to an answering epithalmion of unsurpassed beauty?

The fact that the music of some of the most graceful and beautiful insects is entirely inaudible, though regrettable, has some compensation for the poet. His fancy is free to compose in notes suitable for his ears accompaniments to their varied dances. He may answer for himself the intriguing question

> Hast thou heard the butterflies
> What they say betwixt their wings?
> —*Tennyson, "Adeline."*

His response is sometimes a musical composition of impressionistic and interpretative type, comparable in the grace and beauty of its varied cadences to the dance it accompanies. However, when the poet attempts a literal translation of the insect's music, his composition is as lacking in spirit as the prosaic translation of a foreign poem.

Sometimes the poet, resorting to a little mechanical artifice, attempts a realistic reproduction of the music he hears. Such is "The Bees' Song," which begins with the stanza:

> Thouzandz of thornz there be
> On the Rozez where gozez
> The Zebra of Zee;
> Sleek, striped, and hairy,
> The steed of the Fairy
> Princess of Zee.
> —*De La Mare, "The Bees' Song."*

A somewhat similar feat is performed in "Chimes" with such couplets as—

> Honey-flowers to the honeycomb
> And the honey-bees from home.
>
> A honey-comb and a honey-flower,
> And the bee shall have his hour.
> —*Dante Rossetti, "Chimes."*

In a less artificial and more suggestive stanza, Riley has recaptured something of the sound of the beetle's flight.

> O'er folded blooms
> On swirls of musk,
> The beetle booms adown the glooms
> And bumps along the dusk.
> —*James Whitcomb Riley, "The Beetle."*

The music of the insect, which is produced by apparatus more nearly resembling that of a mechanical instrument than of the human voice, may usually be reproduced, except in the most impressionistic manner, with better effect in instrumental music than in poetry. Composers have vied with poets in beautifully expressing their impressions of the musical flight of insects in such interpretative compositions as "The Dragon-fly,"[46] "The Butterfly,"[47] and "The Fireflies."[48] The composer has surpassed the poet in the realistic reproduction of the music of "The Dance of the Mosquitoes," which was featured by Damrosch in a radio concert last winter. The most celebrated of all insect music is "The Flight of the Bumble-bee," in which Rimsky-Korsakow recaptures the actual sound of flight in a marvelously beautiful and realistic manner.

For long ages man has listened to the song of the insect. Until recently he did not know that the insect received enjoyment from his music. Not only man, but every creature, becomes a "slave of the sound" of music.[49] The sweet music which David played to soothe the troubled soul of Saul held a charm for all creatures that came within the circle of its magic spell.

> Then the tune for which quails on the cornland will each leave his mate
> To fly after the player; then, what makes the crickets elate
> Till for boldness they fight one another;
> —*Browning, "Saul."*

As if in a wood of enchantment, all creatures paused

[46] Nevin.
[47] Greif.
[48] Several composers.
[49] Browning, "Abt Vogler."

Listening to my sweet pipings.
The wind in the reeds and the rushes,
  The bees on the bells of thyme,
The birds on the myrtle bushes,
  The cicale above in the lime,
And the lizards below in the grass,
Were as silent as ever old Tmolus was.
  Listening to my sweet pipings.
—*Shelley, "Hymn to Pan."*

The scientist corroborates the poet's fanciful picture by proofs of the insect's response to the music of orchestra or band, and tries to transform musicians into Pied Pipers to entice the injurious insects to follow them out of the country. He hopes to exact a price for his music far in excess of that charged by insect musicians that took a scant toll from his harvest.

The insect song is perennial. In his lovely little poem to "The Grasshopper and the Cricket," Keats has shown that the "poetry of earth is never dead," that when one insect song is silenced another begins.

Not only during all seasons of the year, but at all hours of the day, some insect song may be heard as an integral part of the great chorus of nature. Morning, noon and night, the tireless chorus continues.

. . . the light of morn, with hum of bees,
Stole through its verduous matting of fresh trees.
—*Keats, "Endymion."*

. . . 'Tis now the hour of deepest noon,
. . . while this multitude of flies
With tuneful hum is filling all the air;
—*Wordsworth, "Excursion."*

The grasshopper is praised as a

Green little vaulter, in the sunny grass,
  Catching your heart up at the feel of June,
  Sole noise that's heard amidst the lazy noon,
When ev'n the bees lag at the summoning brass.
—*Hunt, "Grasshopper and the Cricket."*

In the heat of a later day, even the grasshopper is silenced.

For now the noonday quiet holds the hill;
The grasshopper is silent in the grass;
—*Tennyson, "Oenone," 1: 26.*

In the evening different singers take up the refrain.

At eve the beetle boometh
  Athwart the thicket lone;
At noon the wild bee hummeth
  About the moss'd headstone;
At midnight the moon cometh,
  And looketh down alone.
—*Tennyson, "Claribel."*

At eve a dry cicala sung,
—*Tennyson, "Marianna in the South."*

The coming musk-rose, full of dewy wine,
The murmurous haunt of flies on summer eves.
—*Keats, "Ode to a Nightingale."*

The cricket sang,
And set the sun.
—*Emily Dickinson, CVI.*

The night-wind stirs the fern,
A night jar spins:
—*Masefield, "June Twilight."*

Just as the insect song blends in harmony with any chorus of nature, so, as music at the theater, it interprets the mood or heightens the effect of any drama. The poet has already shown how well insect music fits into any pastoral scene. He also demonstrates the fact that it belongs as well to any stage. He often chooses the versatile cricket's music which fits into many situations, augmenting loneliness or increasing mirth. The "squeak of the cricket"[50] adds to the loneliness of a secluded old woman, its shrill to the desolation of a ruin at twilight or the emptiness of a deserted house. However, Milton's gloomy stage is

Far from all resort of mirth
Save the cricket on the hearth.
—*Milton, "Il Penseroso."*

And at Shakespeare's theater

. . . crickets sing at the oven's mouth,
Aye the blither for their drouth.
—*Shakespeare, "Pericles," 111, Gower 7.*

The atmosphere of brooding tragedy is heightened when Macbeth, on the eve of murder, hears "the owl scream and the crickets cry."

[50] De La Mare, "Alone."

Dormant fears of ghosts are all awakened in

Haunted old rooms: . . .
Where death-ticks knock and mouldering panels
glow.
—*Masefield, "The Death Rooms."*

Isidore, awaiting the arrival of his mortal enemy, in the darkness of a cave hears the

. . . crash of water drops!
These dull abortive sounds that fret the silence
With puny thwartings and mock opposition!
So beats the death-watch to a sick man's ear.
—*Coleridge, "Remorse," IV: 1.*

In the tense stillness of the death chamber, the beating of the deathwatch comes presaging evil with a fearful impressiveness.

Waiting for your summons—
In the night, O, the night!
O, the deathwatch, beating!
—*Tennyson, "Forlorn."*

To some poets insect music is simply jazz—or worse—a mere noise. Henley, a patient in a hospital, petulantly complains:

I can hear a cistern leaking.
. . . .
Like the buzzing of an insect,
Still, irrational, persistent . . .
I must listen, listen, listen
In a passion of attention;
—*Henley, "Nocturne XXVII."*

Tennyson denies the mythological allegation that the grasshopper's song is the voice of the querulous and decrepit old Tithonus, who, at the request of the fair Eos, was granted eternal life, but through her negligence to request eternal youth also, was subject to the ravages of unending age.

No Tithon thou as poets feign
(Shame fall 'em, they are deaf and blind),
But an insect lithe and strong,
Bowing the seeded summer flowers,
Prove their falsehood and their quarrel,
Vaulting on thine airy feet,
Clap thy shielded sides and carol,
Carol clearly, chirrup sweet,
Thou art a mailed warrier in youth and
strength complete.
—*Tennyson, "Tithonus."*

John Hall Wheelock calls the grasshopper's a "fairy song," but Goethe in an entirely different tone remarks:

. . . one of those long-legged grasshoppers,
Who flits and jumps about, and sings forever
The same old song i' the grass.
—*Goethe, "Faust," 1:49.*

Though the grasshopper has such a scant repertoire, his song does not grow monotonous to Shelley, who praises him for singing

Merrily—one joyous thing
In a world of sorrowing!
—*Shelley, "Invocation to Misery," V.*

Color, movement and song rival each other in their attraction for the poet. All these elements are seldom, if ever, found in their greatest perfection in any one insect. The butterfly, the most beautiful, is silent. The cricket, the cicada and the bee are not so colorful but are the most popular singers. The ancient Grecians, revering the butterfly as they did, wrote more poetry about musical insects. Crickets and katydids not only have an esthetic appeal but are of economic interest as well for the natives of South America, Africa, Italy and Portugal, who sell them in ornamental cages as songsters.[51]

Perhaps the music of the insect may never equal that of the bird as a source of inspiration for poetic song. The notes of the soaring skylark, striking upon the responsive strings of Shelley's heart, awoke an echoing melody of matchless beauty. However, the song of the insect blends with the song of the poet in many lovely rhythms. Many poets acknowledge their indebtedness to the insect musicians. Wordsworth said

51 Metcalf and Flint.

. . . my leisure draws
A not infrequent pastime from the hum
Of bees—
—*Wordsworth, "Excursion," 6: 1169.*

And Emily Dickinson charmingly confesses

The murmur of a bee
A witchcraft yieldeth me.

Martin Doule, in his lament for the disillusions of restored sight, recalled with regret the loss of the privilege of "hearing the birds and the bees humming in every weed of the ditch."[52]

Small wonder that Yeats, in dreaming of an ideal home, longed to have

. . . a hive for the honey bee
And live alone in the bee-loud glade.
—*Yeats, "The Lake Isle of Innisfree."*

Nor is it surprising that the poet thinks of Eden as a garden where

Bees, in the cherry-blossom snow,
Rehearsed the earliest honey-humming tune.
—*Eden, "Best Poems of 1927."*

Sleep

Though in infancy the poet is lulled to sleep by the voice of his mother softly crooning

Baby bye,
Here's a fly,
Let us watch him, you and I,
—*T. Tilton, "Baby Bye."*

in manhood he is soothed into slumber by the lullaby of the bee. In the absence of the bee he sometimes behaves as a recalcitrant child, resenting the droning melodies of other insects. Of course, these insects, as impatient nurses, sometimes administer stinging punishments and then increase the tempo and volume of their songs to drown out the cries of the wailing infant. Wordsworth, usually so calm and poised, displays the temperament of a grand opera star in matters pertaining to sleep, which he calls

A Fly, that up and down himself doth shove
Upon a fretful rivulet, now above,
Now on the water vexed with mockery.
—*Wordsworth, "O Gentle."*

However, he enlists the sympathy of all who hear him fretfully complaining that he

. . . could not sleep, tormented by the stings
Of insects, which with noise like that of noon
Filled all the woods:
—*Wordsworth, "Prelude," 6: 712.*

Though he closes his ears to all sounds, and, as a kind of charm to induce sleep, thinks of bees, as one counts sheep, he is still wakeful.

A flock of sheep that leisurely pass by,
One after one; the sound of rain, and bees
Murmuring; the fall of rivers, winds and seas,
Smooth field, white sheets of water, and pure sky;
I have thought of all by turns, and yet do lie
Sleepless!
—*Wordsworth, "A Flock."*

Keats, Shelley, Byron, Coleridge and Tennyson, when weary of singing their own sweet songs, long for the bee to take up the gentle refrain and soothe them to sleep as she sings to the accompaniment of a gently murmuring stream.

Hide me from Day's garish eye,
While the bee with honeyed thigh,
That at her flowery work doth sing,
And the waters murmuring,
With such consort as they keep,
Entice the dew-feathered Sleep.
—*Milton, "Il Penseroso."*

The lullaby of the bee, charming melody that it is, lacks something of the poignant beauty of that heard by Keats when he watches as

. . . the night's sleepy eye
Closes up, and forgets all its Lethean care,
Charm'd to death by the drone of the humming May-fly.
—*Keats, "Hush, Hush, Tread Softly."*

[52] Synge, "The Well of the Saints."

To the lullaby of the bee, man slips into sweet repose; to the dirge of the beetle, he sinks into sleep eternal. Keats, in his "Ode on Melancholy," says

Nor let the beetle, or the death-moth be
Your mournful Psyche.

In Gray's "Elegy in a Country Churchyard"

. . . all the air a solemn stillness holds,
Save where the beetle wheels his droning flight.

When the raven dies, he, too, wants to go to his last rest to the strains of the beetle's funereal music.

Summon the haunted beetle,
From twilight bud and bloom,
To drone a gloomy dirge for me
At dusk above my tomb.
Beseech ye too the glowworm
To rear her cloudy flame.
—*De La Mare, "The Raven's Tomb."*

Both gnats and crickets join in a dirge to the dying year:

Then in a wailful choir the small gnats mourn
Among the river shallows, borne aloft
Or sinking as the light wind lives or dies;
And full-grown lambs loud bleat from hilly bourn;
Hedge-crickets sing;
—*Keats, "To Autumn."*

The poet as musician transposes the song of the insect to harmonize with any melody he sings, as artist he reproduces its color to blend with any hues on his canvas, as sculptor he models its form into images of thought of greater beauty and variety than the most superb statues ever molded from

The waxen labour of Hymettus' bees,
By plastic fingers wrought, to various shape
And use by use is fashioned.
—*Ovid, Greek Anthology.*

The Lover

Poetic fancy flies with honey-hunting insects and rests in charming revery upon the flowers. The courtship of insects and flowers is a delicate and beautiful theme.

. . . birds, and butterflies, and flowers,
Make all one band of paramours.
—*Wordsworth, "Green Linnet."*

The flower, enamored of the butterfly, pleads that he "wanton not from spot to spot"[53] but remain her constant lover. Love-lorn flowers dream "of moths that drink them under the moon."[54] Cupid reverses his arrow and the butterfly becomes the wooer.

With the rose the butterfly's deep in love,
A thousand times hovering round;
But round himself, all tender like gold,
The sun's sweet ray is hovering round.
—*Heine, "New Spring Song," 7.*

Auto-da-fé and judgment
Are nothing to the bee;
His separation from his rose
To him seems misery.
—*E. Dickinson, LXXI.*

Insects, so charming in their own courtships, fly to the assistance of the poet in his affairs of the heart. The lover often chooses insects to convey messages to his beloved. Meleager asks a mosquito to fly swiftly to Zenophila and whisper into her ear his words of invitation, and promises rich rewards if he entice her to come.[55] However, the lover seldom entrusts his all-important errand to a less trustworthy messenger than the bee. Herrick, with an extravagance not only excusable, but charming, in an infatuated suitor, sends the bee as a messenger but threatens to make him both sexton and mourner if his mistress reject his gift.

Fly to my Mistresse, pretty pilfring Bee,
And say, thou bring'st this Hony-bag from me:
When on her lip, thou hast thy sweet dew plac't,
Mark, if her tongue, but sloly, steale a taste.
If so, we live; if not, with mournfull humme,
Tole forth my death; next, to my buryall come.
—*Herrick, "The Present."*

53 Hugo, "Flower to Butterfly."
54 H. Brooke, "Great Lover."
55 Patou, "The Greek Anthology."

Man, when a fickle lover, darting from paramour to paramour, finds an exact counterpart in "The Butterfly Beau,"[56] flitting from flower to flower, tasting all their sweets and being true to none. Yet a Scottish maid, in an oath of constancy, swears

While bees delight in opening flowers;
While corn grows green in simmer showers,
I'll love my gallant weaver.
—*Burns, "The Gallant Weaver."*

The rejected lover of Amaryllis modestly prays

Look on me kindly, and some pity show,
Or give me leave at least to look on you.
Some god transform me by his heavenly power,
E'en to a bee to buzz within your bower,
The winding ivy-chaplet to invade,
The folded fern, that your fair forehead shade.
—*Theocritus-Dryden, "Amaryllis."*

Romeo, banished, envies the flies their intimacy with Juliet.

. . . more courtship lives
In carrion flies than Romeo: they may seize
On the white wonder of dear Juliet's hand,
And steal immortal blessing from her lips;
Who, even in pure and vestal modesty,
Still blush, as thinking their own kisses sin;
But Romeo may not; he is banished,
This may flies do, when I from this must fly.
—*Shakespeare, "Romeo and Juliet," III: 3*

What lady could refuse a plaintive request for a kiss when her lover willingly metamorphoses himself into a bee and flatteringly implies that her lips are a rose?

But, Delia, on thy balmy lips
Let me, no vagrant insect, rove;
O let me steal one liquid kiss,
For, oh! my soul is parched with love!
—*Burns, "Delia."*

With little coaxing Philly grants her lover a kiss. He leaves no doubt as to his appreciation when he says:

The bee that through the sunny hour
Sips nectar in the opening flower,
Compared wi' my delight is poor,
Upon the lips o' Philly.
—*Burns, "Philly and Willy."*

Donne presents a circuitous argument for undue liberties, contending that his blood and that of the lady to whom he is paying court are mingled in the flea which has bitten them both. The lady indignantly kills the flea. Then Donne, not to be outdone, turns this episode to his account, remarking

Yet thou triumph'st, and say'st that thou
Find'st not thyself nor me the weaker now.
'Tis true; then learn how false fears be;
Just so much honour, when thou yield'st to me,
Will waste, as this flea's death took life from thee.
—*Donne, "The Flea."*

In striking contrast to Donne, Shelley gives expression to a beautiful, etherealized love.

I can give not what men call love,
But wilt thou accept not
The worship the heart lifts above
And the Heavens reject not,
The desire of the moth for the star,
Of the night for the morrow,
The devotion to something afar
From the sphere of our sorrow?
—*Shelley, "One Word."*

Lovers of to-day, as those of long ago, choose from the bee's vintage liquid terms of endearment. From the pages of Chaucer the lips of a lover frame again the words

. . . Honycomb, sweete Alisoun,
My faire bryd, my sweete cynamone.
—*Chaucer, "The Miller's Tale."*

The sweetness of a "honied" courtship is but changed in marriage to

The lusty lyf, the vertuous quyete,
That is in mariage hony sweete;
—*Chaucer, "The Merchant's Tale."*

The Poet

Shelley, though denounced by moralists as a worm, has unravelled the

[56] T. H. Bayley, "Butterfly Beau."

threads of the coarse mantle of scorn thrown about him and rewoven them into a fabric, sheer and lovely, matching in texture the web of the most skilled insect artisan.

The silk-worm in the dark green mulberry leaves
His winding sheet and cradle ever weaves;
So I, a thing whom moralists call worm,
Sit spinning still round this decaying form,
From the fine threads of rare and subtle thought—
No net of words in garish colours wrought
To catch the idle buzzers of the day—
But a soft cell, where when that fades away,
Memory may clothe in wings my living name
And feed it with the asphodels of fame.
—*Shelley, "Letter to Marie Gisborne."*

Though the poet satirize some of his fellow artists and their style by comparing them to certain insects, he shows a fond predilection for picturing himself and the poets he admires as other insects. Perhaps his partiality for bees may be traced to his miraculous deliverance from starvation by their intervention.

And, O Theocritus, so far have some
Prevailed among the powers of heaven and earth,
By their endowments, good or great, that they
Have had, as thou reportest miracles
Wrought for them in old time: yea, not unmoved,
I hear thee tell how bees with honey fed
Divine Comates, by his impious lord
Within a chest imprisoned; how they came
Laden from blooming grove or flowery field,
And fed him there, alive, month after month,
Because the goatherd, blessed man! had lips
Wet with the Muses' nectar.
—*Wordsworth, "Prelude," II: 443.*

The poet, his methods and his works are complimented by insect analogies. When gaining impressions that were later to be translated into his poetry, Wordsworth, looking out over a wide expanse of water, was

. . . gathering as it seemed,
Through every hair-breadth in that field of light,
New pleasure like a bee among the flowers.
—*Wordsworth, "Prelude," I: 580.*

In highest tribute to Pindar, before whose melody all other lutes were mute, Antipater praised:

Not vainly did the swarm of brown bees drip
Their wax-bound honey on your infant lip.

Menander is similarly praised.

"The bees themselves on thy lips honey dropped."[57] "Honer with the honey mouth"[58] and Shakespeare smiling from the "honeyed corner at his lips,"[59] have given to the world a rich legacy of words that "been honeycombes, for they geven swetnesse to the soule and hoolsomnesse to the body."[60]

What more beautiful illustration of the inspiration of the poet than that of the nightingale, most superb of all singers, feeding upon the glowworm.

For as nightingales do upon glow-worms feed,
So poets live upon the living light.
—*Bailey, "Festus, Sc. Home."*

Listening in rapt attention to the poet's "honeyed" words, people

. . . on his eloquent accents fed and hung
Like bees on mountain-flowers:
—*Shelley, "Revolt of Islam."*

Or, as Lucretius says in praise of Epicurus,

As the bees in the flower-grown meadows take the
sweets from all the flowers, so we also satiate
ourselves with your golden sayings, golden indeed,
and ever worthy of endless life.
—*Lucretius, "De Res. Nat.," 3: 11.*

The sonnet has been lauded by many poets, but perhaps nowhere with happier effect than by Wordsworth when he says:

The Sonnet glittered a gay myrtle leaf
Amid the cypress with which Dante crowned
His visionary brow; a glow-worm lamp,
It cheered mild Spenser, called from Faery-land
To struggle through dark ways;
—*Wordsworth, "Scorn Not."*

57 Anon., On Menander, Greek Anthology, Collins.
58 Chaucer, "Boethius," Bk. 5, N 2.
59 Meredith, "Spirit of Shakespeare."
60 Chaucer, "Melibeus."

(To be concluded in the next number)

SCIENCE SERVICE RADIO TALKS

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THE MAGNETISM OF THE EARTH

By J. A. FLEMING

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THE earth is a great spherical magnet. Unlike the force of gravitation, the earth's magnetism is a phenomenon which we can not immediately recognize through our physical senses. An unexpected fall tells you forcibly of the existence of gravitation but you never notice any effect from the earth's magnetic force although it is as real as that of gravity.

The discovery of the lodestone or natural magnetic rock with its mysterious power of attracting objects made of iron was the first step in the study of the earth's magnetism. This magnetic property of the lodestone—the so-called leading stone of the Scandinavians, the loving-stone of the French—was known to the Greeks over six hundred years before Christ. As is the case for so many discoveries, the Chinese are credited with an earlier knowledge of the directive property of the lodestone. Chinese legends 2,600 years before the Christian Era tell of the south-pointing war-chariot. In Japan south-pointing carts were known in the seventh century. Europeans did not become acquainted with the properties of the lodestone until about four hundred years later.

In experimenting with lodestone it was found that when mounted on a block of wood and floated in water it always indicated the north-south direction. This paved the way for the development of the magnetic compass by European navigators beginning in the eleventh century. The voyage of Columbus, in 1492, showed that the compass direction changes from place to place. In 1576, it was discovered that one end of a compass needle supported on a horizontal axle would dip below the horizon. In 1600, William Gilbert concluded from the behavior of the compass needle in different parts of the earth that the earth itself acts like a great spherical magnet. His discovery thus preceded that of universal gravitation by Newton. The earth is a feeble magnet, for it is not highly magnetized. It is possible to magnetize our modern hard steels ten thousand times as much as the earth. Even at that, since the earth is large its total magnetism is equivalent in effect to that of eight hundred quintillion one-pound magnets of our best magnet steel could they be placed at the center of the earth.

The earth is not uniformly magnetized and the principal magnetic poles, those places where the inclination is 90°, are distant 1,200 miles or more from its geographic poles. The north magnetic pole, the region of which was first visited in 1831 by Ross and again in 1903 by Amundsen, is on Boothia Peninsula in northern Canada approximately in latitude 70° north and in longitude 96° west. The south magnetic pole, in South Victoria Land, has not yet been surveyed; it is approximately in latitude 73° south and in longitude 156° east. Thus the magnetic poles are not diametrically opposite each other, the line joining them passing some 750 miles away from the center of the earth.

The earth's magnetism extends its in-

fluence or magnetic field far out into space. The field at a distance of 4,000 miles above the earth's surface is still one eighth as great as at the surface. One may picture the field as made of innumerable lines of magnetic force or action closely packed together. Near the equator these lines of force are parallel to the earth's surface, but as they approach the magnetic poles they bend and converge. Minute electrified particles are coming continually from the sun. Once within the earth's magnetic field, these particles or corpuscles travel in paths around the lines of magnetic force. They get deeper down in our atmosphere in the polar regions, where the magnetic-force lines are steepest. When the electrified particles pass through the atmosphere, they are made to glow by the resistance encountered. These glowing particles cause the brilliant polar-light displays we sometimes see in the northern sky and which are also seen in the southern sky by people living in the southern hemisphere. From simultaneous photographs of aurora it has been found that polar-light beams generally do not come closer to the earth's surface than about 60 miles and have been observed to heights of 300 miles and more.

We investigate the earth's magnetism by studying its field or its effects outside the earth. There are many regions where local magnetic disturbances, for example, those caused by magnetic ore deposits, give rise to local poles and to further irregularities in the earth's general magnetic field. Therefore, magnetic observations must be made at many places to determine with reasonable correctness the distribution of the earth's magnetism.

There are also progressive changes in the earth's magnetic elements. These vary from place to place and for the same place from time to time. Such progressive changes or secular variations were first noted by Gellibrand in 1634. The importance in any practical use of the magnetic compass of these changes may be realized from observations at London made during the past 350 years. There the magnetic needle pointed 11° east of north in 1580, 24° west of north in 1812, and since then has again shifted eastward and now points only about 13° west of north. These results indicate that there is a complete cycle of change in the direction of the compass needle in about 500 years. Centuries more of observations will be needed to verify these indications.

The complexity of the earth's magnetism is further shown by other perplexing periodic and irregular changes or variations. There is a daily variation which varies with time, position on the earth, season, and sun-spot frequency and other cosmical relations. There is also an annual inequality.

More fascinating than these periodic variations are the irregular ones of various types. These frequently occur almost simultaneously over the whole globe, their violence increasing generally as the place of observation is nearer a magnetic pole. These magnetic storms are in general simultaneous with displays of the polar lights. They are associated with the number and size of sun-spots and increase with increased sun-spot activity. They also are frequently accompanied by pronounced disturbances of the natural electric currents within the earth, that is, earth-currents. If severe, they often prevent telegraphic and radio communication, thus taking an important place in everyday practical affairs. They bear no relation to stormy weather conditions. In the stormiest weather there may be no magnetic storms while during the finest weather there may be a severe magnetic storm in progress.

Since the magnetic state of the earth is so complex and subject to so many influencing factors, observations must

be obtained at many points. This is done by systematic magnetic surveys and by operating magnetic observatories. Such magnetic surveys and observatories are maintained by a majority of the nations of the world. In the United States this work is in charge of the Coast and Geodetic Survey of the Department of Commerce. In addition to its field observations, the survey operates five magnetic observatories, one in Maryland, one in Arizona, one in the Hawaiian Islands, one in Alaska, and one in Porto Rico. Since 1904 the Carnegie Institution of Washington, D. C., has maintained a department of terrestrial magnetism for the study of the earth's magnetism and electricity and to complete the earth's magnetic survey by observations on land in those countries where there are no systematic surveys and over the oceans. For the observations at sea that institution designed and constructed the non-magnetic ship *Carnegie*. This vessel was unfortunately destroyed in November, 1929, by fire in Western Samoa. From 1909 she cruised over 300,000 nautical miles in all oceans and had completed the general magnetic distribution survey of the oceans. Magnetic-variation charts for the ocean regions, so important to the safety of shipping, have for many years utilized to a great extent the observations made on the *Carnegie*. This institution also operates two magnetic and electric observatories in the southern hemisphere where, of the world total of about seventy, there are only eleven observatories. One of these is some 120 miles north of Perth at Watheroo, Western Australia, and the other is at Huancayo, Peru, about 120 miles east of Lima in the high Andes at an elevation above sea of two miles.

Recent analyses of available magnetic data between latitude 60° north and 60° south by the Carnegie Institution of Washington show that over nine tenths of the total magnetic field arises from magnetic or electric systems within the earth and the remaining part from similar systems outside the earth. Additional observations to improve these analyses are needed in polar regions, where the transient magnetic and electric variations and storms are extremely emphasized because of the proximity of the earth's magnetic poles. Thus the additional reliable observations in these regions proposed by the Wilkins-Ellsworth Trans-Arctic Submarine Expedition for 1931 and by the many polar stations proposed in the program of the International Polar Year Commission for 1932–33 are of exceptional importance.

Observations during the last century at stations in Europe and in the United States have revealed the close relation between sun-spot activity and disturbances of the earth's magnetism. Another interesting feature of the earth's magnetic activity is that as the earth revolves about the sun the maximum changes in magnetic, earth-current, and polar-light activity occur during the equinoctial months of March and September, and the minimum during the solstitial months of June and December.

We have not yet learned definitely the cause of the variation in the earth's magnetic field. Despite this, magnetic observations have added materially to our knowledge of the earth's interior, particularly to some of the geological features of the earth's crust. Thus the secular variation suggests changes within the crust, indicating an interior more mobile than the exterior layers. These studies give us additional information regarding the high atmosphere above the earth and, in particular, regarding the Kennelly-Heaviside layer. Observations of fluctuations in height of this layer show its fundamental importance in terrestrial magnetism and in radio transmission.

The penetrating radiation or cosmic

rays from space may be the connecting link to tie together in a satisfactory theory the present indications of the sun and of the variable electric currents in our atmosphere and within our globe as the ultimate causes of the earth's magnetism and its variations. Therefore, laboratory experiments have been conducted for some years by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in the study of the structure of the atom and its magnetic properties through the artificial production of high-voltage radiations. Another connecting link may be in possible modifications in the physical properties in the higher atmosphere from those in lower altitudes of which we know. Researches in this connection await development of rockets capable of reaching heights from 25 to 50 miles or even more. Recent tests indicate early realization of technique to accomplish this.

HUNGER

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Modern research on man and animals permits us to state the following facts concerning the nature and control of hunger. Whether we use the word hunger in its widest or most limited sense, it describes one of the most common and most important experiences of living organisms. Hunger pangs have been felt by every individual of the human race and have unquestionably determined many of the actions of their lives. Whether other animals besides human beings feel hunger pangs is still a matter of conjecture, but, if we employ the word hunger in its quite legitimate sense as the total of conditions determining the ingestion of food, we shall not exaggerate in saying that hunger is the most potent single influence in life. At times the sex urge is more of a drive to activity, but the sex stimulus is dormant in childhood and fails with advance in years, while hunger is potent throughout life.

Despite the commonness of the hunger sensation(to return to the more limited definition of the word), our knowledge of its real nature is far from final. It is not even easy to describe our subjective experience of it. If we call it emptiness or hollowness, we are not really describing what we feel. Instead we are expressing our knowledge that our stomach is empty of food when we feel that uncomfortable sensation in our midregion. The hunger sensation can be correctly described as painful epigastric tension and pressure, but this, too, is unsatisfactory.

A charactertistic element in the hunger complex is its intermittency, its occurrence in sharply defined periods. This is true even though the stomach is continuously empty and the physical activity of the individual is uninterrupted. It seems to hold also for other mammals and for birds. In the lower animals, to judge by the motion of the empty stomach, it is nearly continuous.

Although in normal persons the hunger sensation must become exceptionally strong to be markedly painful, the epigastric sensation of varying degrees of pain is the indispensable subjective element. Frequently, however, there is a feeling of general lassitude or weakness. Sometimes headache, nausea, nervous irritability, restlessness and even fainting may appear as a part of the hunger complex. Strictly speaking, a certain degree of nervous excitability is a necessary effect of hunger of even moderate intensity, but in normal persons with stable nervous organizations

strong hunger is seldom accompanied by any of these obvious manifestations of nervousness. In some individuals, on the other hand, the accessory phenomena may be so marked as to crowd out of consciousness the central factor of hunger, the gastric hunger pangs.

When we feel hungry, why do we eat? The obvious reply is that we know that eating will relieve us of the pangs. But how did we learn? A new-born infant can not know what effect the ingestion of food will have on the hunger sensation, because he has never had food in his stomach. What induces the new-born animal to take food? Is it a matter of inherited reflexes (instinct)? The feeding reflexes are present at birth, and so are the defensive ones which reject unpalatable and injurious substances. We have seen that hunger increases excitability. Hunger then probably causes the infant to put more things into his mouth, to be either swallowed or rejected. Palatable materials in the mouth and any materials in the stomach stop the hunger pangs, and the infant animal learns by the trial-and-error method that by eating discomfort is changed to comfort.

The exact cause of the hunger sensation is still a matter of dispute, although, to my mind, the theory of peripheral origin has been conclusively proved but not completely worked out. The peripheral theory holds that the hunger sensation is inaugurated in sensory nerve endings, mainly in the upper part of the digestive tract (stomach, lower esophagus and small intestines). Some investigators hold that the origin of hunger is in a hypothetical hunger center of the brain, which is stimulated by food deficiencies in the blood or brain tissues. There is experimental evidence that hunger may, in fact, often does, begin even before the stomach is completely empty and long before there could be any food deficiency in the blood or tissue. It has further been shown by experiment that hunger pangs coincide almost identically, both in time and intensity, with certain strong rhythmic contractions of the stomach, which begin as the stomach is emptying and continue in intermittent groups until inhibited by the ingestion of some material or by some abnormal condition, such as strong emotion or the action of drugs. These contractions have been termed hunger contractions. I regard as conclusive proof that hunger pangs are initiated by these contractions (through some sensory mechanism which has not yet been determined) the fact that an artificially stimulated hunger contraction in an otherwise quiescent stomach will invariably give rise to a hunger pang.

The existence of intermittent hunger contractions, as well as the several other types of movements of the stomach, has been ascertained by several methods of objective observation on the stomachs of normal and abnormal man and animals. The stomach may be observed either directly through a fistula, by means of the x-ray and barium in the stomach, or with the aid of a balloon, which, when inflated in the stomach and connected by a rubber tube to a recording instrument, will yield a continuous record of its movements.

In the normal human being a single hunger contraction endures on an average of 30 seconds. They come in periods of from 30 to 45 minutes, which are separated by periods of repose from 30 to 150 minutes long. The individual contractions in each period are separated by periods of quiescence at first but are practically continuous at the end. In infants the periods of quiescence are shorter, gradually increasing to reach their maximum in senile old age. This is what we would expect, knowing that body metabolism (rate of food combustion) decreases gradually from youth to old age. The stomach muscles do not seem to share completely

this decline, since starvation, even in old age, will give rise to strong contractions.

The stomach is supplied with various sensory and motor nerves from the central nervous system. The function of these nerves seems to be, in general, one of modification, similar to that of the nerves to the heart in the regulation of the heart rhythm. Even when all the central nerve connections are severed, the stomach exhibits typical hunger contractions. In sleep, hunger contractions are more vigorous and regular than in the waking state. During sleep there is a general decrease in activity of the central nervous system, evidenced by decreased activity in all the other neuromuscular mechanisms, such as skeletal muscles, blood vessels and urinary bladder. One might expect to find the same condition in the empty stomach. The phenomena of increased activity indicates that the tonus mechanism of the stomach occupies a unique place in the organism.

Emotional states of the higher nerve centers, such as anger, fear and joy, inhibit hunger contractions. Intellectual states, such as attention, reading and reasoning, have no distinct effect on the course of the hunger period. Contrary to popular belief, the sight or smell of food does not intensify hunger contractions; if there is any effect it is in the other direction. In this case the hunger pangs are probably reinforced through some central mechanism. The basis for the view that hunger "cravings" can be changed at will is probably to be found in the fact that mild hunger contractions do not enter consciousness if the attention of the individual is diverted in any way. The attention to hunger is usually aroused, consciously or unconsciously, about the time the individual is accustomed to eat. Therefore, if he changes that time, he can to a certain extent change his experience of hunger pangs.

One of the chemical factors in the blood that has been shown to influence gastric hunger contractions and the conscious hunger sensations is the sugar. When the blood sugar is markedly decreased hunger is increased, and *vice versa*. This is probably one of the reasons we can so quickly appease hunger with candies or sugar, as this type of food enters the blood quickly.

Hunger is increased in such diseases as diabetes. It is decreased in fevers and in most disorders of the digestive system. Hunger is not directly influenced or increased by tonics. Appetite seems to be merely the memory of past experience (sight, taste, smell) with food. Appetite is therefore a pleasant subjective process or sensation, while hunger is built into the very framework of the animal machine and is not essentially modified by the experiences of the individual, except as this induces strong emotional states.

The hunger pangs, due to the strong contractions of the empty stomach, continue throughout fasting almost to death. The view that hunger disappears after a few days' fasting is an error. But disturbances in our conscious life can overshadow our hunger feeling or even change it to nausea. Thus we see that the working of the hunger mechanism requires a normal stomach with its sensory nerves, and also a normal or nearly normal brain. In the normal person, the hunger felt, even in prolonged starvation, is uncomfortable, but not actually or acutely painful. There is no heroism in "Hunger strikes."

AT THE HEAD OF THE CACAPON

By Dr. J. G. NEEDHAM
CORNELL UNIVERSITY
and P. D. STRAUSBAUGH
WEST VIRGINIA UNIVERSITY

In Hardy County, West Virginia, a small clear river comes tumbling down between two of the parallel ridges of the Allegheny Mountains, and at the foot of Sandy Ridge, which lies across its further course, it descends into the earth. It goes down through a number of gravel-filled holes in its limestone bed, gurgling a bit noisily in some of them, and with a sound of falling water in the distance underground. Thus it disappears from view, to reappear some three miles distant on the other side of the ridge, like a great upwelling spring. It gets another name in the process. Before it disappears underground it is known as Lost River; after its reappearance it is the Cacapon.[1]

This stream is well enough known[2] to geologists, who have taken much interest in it. Its course is fairly well shown in the Wardensville topographic quadrangle of the U. S. Geological Survey. It should be better known to biologists, especially the portion of the head of the Cacapon; for here is a very unique environment that shelters wonderfully interesting flora and fauna.

It is our purpose in these pages to call attention to some of the things of interest that were found at the head of the Cacapon by the members of the West Virginia University Biological Expedition during the week of their encampment near Wardensville, in August, 1930.

The river emerges from its long course underground well filtered. Its waters are clear and sparkling. They run glistening down the riffles, and settle in pools of wonderful transparency. Fishes swimming in the pools and water plants swaying in the current are seen almost as clearly as through air; and even the fine silken nets of the caddisworm, Hydropsyche, that elsewhere are commonly hidden under a load of adherent silk, here stand out clearly showing the meshwork of their white threads. The waters are remarkably clear.

The steep mountain sides on either bank of this winding stream are covered with forest, much of which is still of primeval aspect. Azaleas, laurels and rhododendrons peep out from under the edges, and where the foot of the slope meets the stream there are great banks of royal fern. Elsewhere willows and alders crowd the streamside, with tall wands of meadow-rue and Jo-pye-weed and tufts of bulrush and flaming spikes of cardinal flowers rising here and there among the rocks. The gradient is moderate for a mountain stream, but sufficient to maintain long stretches of rocky rapids and a few low waterfalls, with pools of gentle onflow lying between. There are long stretches of uptilted rock ledges over which the water breaks in shallow riffles and these ledges are thickly covered with a dense inch-high vegetation consisting mainly of the curious leafless waterweed, Podo-

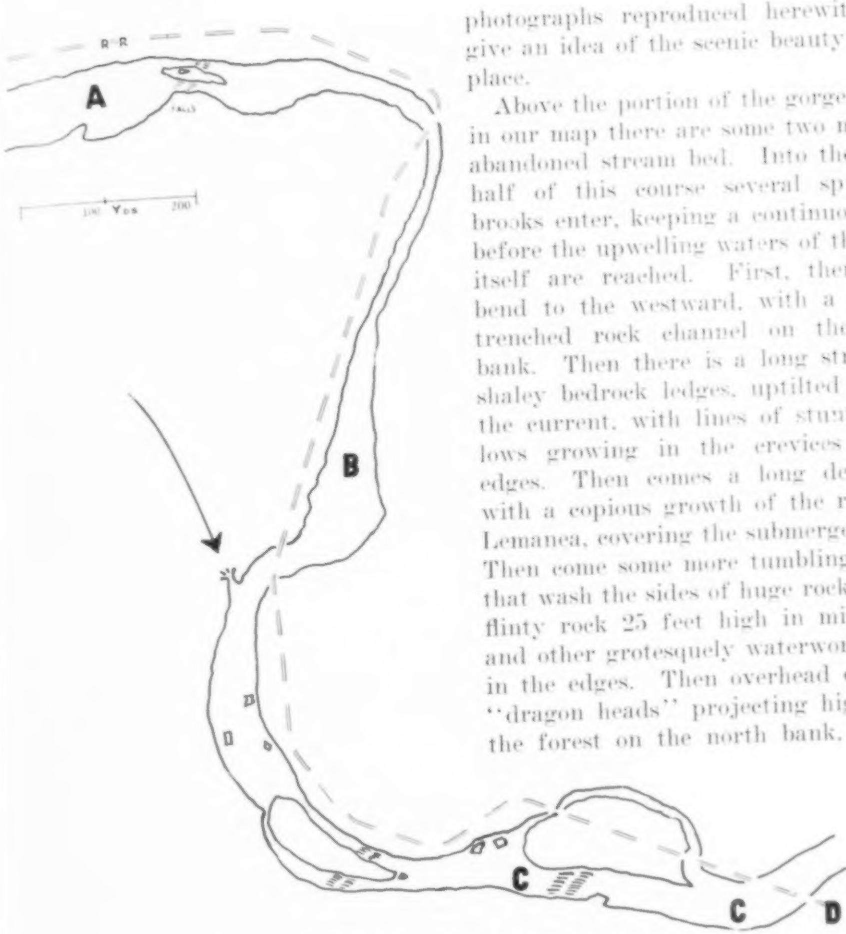
[1] Indian name "Kaka pon-de-pe" (according to Conley's Encyclopedia of W. Va.) signifies "River of Medicine Waters" and was doubtless suggested by the numerous springs of therapeutic value along its course.

[2] George Washington visited it on horseback (as recorded in his diary) on April 10, 1747, in the course of a thirteen months' surveying trip made when he was 15 years old.

stemum and mosses. In the clear pools float cumulous masses of algae. The bottom of the pools is formed of broad flat rock, with sparse swaying tufts of waterweeds growing in the crevices. There is but little place for the lodgment of sand and gravel.

Herewith we present a sketch map of a portion of the channel near the head of the Cacapon. It shows the succession of pools and waterfalls, and the photographs reproduced herewith will give an idea of the scenic beauty of the place.

Above the portion of the gorge shown in our map there are some two miles of abandoned stream bed. Into the lower half of this course several springfed brooks enter, keeping a continuous flow before the upwelling waters of the river itself are reached. First, there is a bend to the westward, with a narrow trenched rock channel on the north bank. Then there is a long stretch of shaley bedrock ledges, uptilted against the current, with lines of stunted willows growing in the crevices at the edges. Then comes a long deep pool with a copious growth of the red alga, Lemanea, covering the submerged rocks. Then come some more tumbling rapids, that wash the sides of huge rocks—a big flinty rock 25 feet high in midstream, and other grotesquely waterworn blocks in the edges. Then overhead come the "dragon heads" projecting high above the forest on the north bank, the picturesque upstanding edges of vertical thin strata of hard rock. Then in the channel there is a long stretch to the southward with alternating stagnant pools and dry bare rocky river bed.



SKETCH MAP OF THE HEAD OF CACAPON RIVER.

Arrow indicates where the river merges from under the mountain; above it lies the flood-water channel, in which, in the portion here shown, water is kept flowing by spring-fed tributary brooks. *A*, Isoetes pool; *B*, Long pool; *CC*, Bass pools, *D*, the foot of the gorge and entrance from the Wardensville (eastern) side; *RR*, Log railroad.
Prepared by A. F. Rohrbough, N. B. Green, R. K. Brown and R. E. Douglas.

Doubtless the underground course of this stream is a solution channel formed recently (if we speak in terms of geologic time) by the dissolving of the limestone of the river's bed. For the river flowed on the surface long enough

ONE OF THE BASS POOLS IN THE CACAPON RIVER
THIS AND THE FOLLOWING PHOTOGRAPHS TAKEN BY MISS MYRTLE MILLER.

to cut the mountain ridge in two and to make this sinuous, picturesque, rocky gorge across it. Flood waters still run on the surface, roaring among the bare rocks of the channel that lies all the way in the bottom of this gorge. We visited it at low water, when for more than a mile below the end of Lost River there was no running water to be seen, only a channel lined with bare waterworn rocks, with now and then a residual pool.

It is the aquatic life of this place that is of especial interest because of its abundance and variety. The richest portion of the Cacapon is that covered by our sketch map, the portion near the place where the river emerges; and it is to this that we wish to call particular attention.

ANIMALS

There was nothing remarkable about the vertebrate fauna found at the head of the Cacapon. The following fishes were seen by us:

Hog fish
Black bass
Rock bass
Silver-mouthed minnow
Silver-fin minnow
Spot-tail minnow
Blunt-head minnow
Silver-sides minnow
Cut-lips minnow
Dough-belly minnow
Storer's chub
Sculpin
Johnny darter
Catfish

The only other aquatic vertebrates noted were a few salamanders and a water snake.

The invertebrate fauna was very rich. With screens we collected from among the rocks in the riffles larvae of the following aquatic insects:

Stone-flies
Pteronarcys
Perla
Acroneuria
Peltoperla
Leuctra

May-flies
Heptagenia
Epeorus
Ecdyonurus
Chirotenetes
Leptophlebia
Baetis
Ephemerella
Choroterpes

Caddis-flies
Rhyacophila
Hydropsyche
Philopotamus
Chimarrha
Goera
Leptocerus
Brachycentrus
Psilotreta

Dragon-flies
Argia
Boyeria

Beetles
Psephenus
Dryops
Helichus
Elmis
Stenelmis
Ancyronyx
Macronychus

Two-winged flies
Atherix

Simulium
Chironomus
Ceratopogon
Tanytarsus
Eriocera

Tipula

Dobson flies

Corydalis
Chauliodes

In these same riffles, spot-bound on the rocks, there were two curious caddis-worms: Helicopsyche, with its tube of sand grains wound in a spiral, like a snail shell; and Ithytrichia, with its flat lenticular alga-covered case of silk adhering to the upper surface of submerged stones.

Among the rocks at the outflow of the Long Pool (B of map), there was a good growth of fresh-water sponge (Spongilla) and in the osteoles of the sponge we found the little Neuropterous spongilla fly, Climacia, living. The sponge masses were perforated with the tubes of a midge larvae, and furrowed with the tracks of the caddis-worms, *Leptocerus ancylus*.

On the surface of the pools there were whirligig beetles, Dineutes and water striders, Gerris and Rhagovelia, and marsh treaders, Limnobates. In the edges were the usual pond beetles Tropisternus, Hydroporus, etc.; also dragon-flies, Tetragoneuria, etc.; damsel-flies, Enallagma and Ischnura; and caddis-flies, Halesus, Limnophilus, Setodes, Mystacides, etc. A few nymphs of the slender damsel-fly, *Agrion angustipenne*, were found clinging to the swaying leaves of trollops (Heteranthera), swaying in the current.

Bottom sprawlers on the silt and sand were the flat long-legged spider-like dragon-fly nymph, Macromia, the still flatter black Hagenius and the stouter Neurocordulia; also the hairy little silt-covered May-fly, Caenis; also the caddis-worm Molanna, whose flat, wide-winged portable case of sand has an extension, like a portico roof over the front door. Burrowers in the bottom sand were of several groups; the May-flies, Hexagenia, Ephemera and Ephoron; the dragon-flies Lanthus, Gomphus and Dromogomphus; the orl fly, Sialis; the deer-fly Chrysops; the tube-dwelling caddis-worm, Phylocentropus, and the midge, Chironomus.

Hidden in the dense inch-high vegetation that covers the rock ledges at the outlet of the lower bass pool were multi-

THE UPWELLING WATERS OF THE CACAPON,
EMERGING AT THE FOOT OF THE MOUNTAIN AFTER THEIR THREE-MILE COURSE UNDERGROUND.

ISOETES POOL IN THE GORGE ABOVE THE HEAD OF THE CACAPON
ONE OF THE CHOICE COLLECTING SPOTS FOUND BY THE WEST VIRGINIA UNIVERSITY BIOLOGICAL EXPEDITION OF 1930.

tudes of the net-making caddis-worms, Hydropsyche, the May-flies, Ephemerella (2 species), Baetis and Caenis, the midge, Chironomus, the stone-fly, Perla, and the predatory fly, Atherix.

All these animals and others, including a goodly variety of snails, leeches, flatworms and hydrachnids, were found in the two short trips we made to the head of the Cacapon. These are surely sufficient to indicate that it is an exceptionally good collecting ground.

PLANTS

It is quite impossible to gave an adequate word picture of the luxuriant aquatic vegetation growing in the constantly varying habitats of the upper waters of the Cacapon. At every turn in the course of this ever-changing stream one may expect to see in its limpid pools, in the tumbling waters of its noisy cataracts, or in the quieter stretches, something novel and unexpected. The wet rock surfaces and moist sand flats along the border are choice situations for numerous liverworts and mosses.

In the deep pools large masses of algae, *Mougeotia* and *Spirogyra*, hang suspended in the clear, quiet water, suggesting a mirror image of clouds in a blue sky. Where the water tumbles swiftly over rocky ledges there were lush carpets of water mosses covering the rocks, and apparently several species are represented. In the extensive pool (A of the map) just above the falls we came upon a colony of *Isoetes*. Some of these plants were found growing on the sand flats just above the water level but the greater number were found on the rocky bed of the stream, from two to three feet below the surface of the water. At the point where the river emerges from the mountain there is an abundance of the red alga, *Tuomeya*.

In the shallower parts of the river and along the banks, particularly where the fringing trees or rock walls do not exclude the sunlight, there are extensive beds of *Potamogeton* and *Heteranthera*. Caught in the meshes formed by the branches and leaves of these plants there were great numbers of dark-green, irregularly vesicular, algal bodies which

when examined, were found to be specimens of *Nostochopsis lobatus*. This alga grows very loosely attached to the rocks, and since this attachment is easily broken, these plants are commonly found floating on the water behind logs, rocks or other obstructions, such as floating vegetation. In several places we found the flat, leathery, disk-like thalli of *Nostoc muscorum* growing on the surface of the rocks in shallow water, and these plants were objects of very special interest to the entomologists of our party, for there was found a midge larva dwelling inside almost every plant examined. Another blue-green alga, *Oscillataria tenebriformis*, occurs here in abundance. This is a most interesting species of Oscillatoria in which the terminal portion of the filaments coils up to form a very close spiral. *Spirogyra crassa*, one of the giant forms of the genus, thrives here and can be collected in quantities.

At a point near the island (just above C on the map) there is a splendid colony of *Marchantia polymorpha*. Some of these plants are growing on the damp soil near the river margin but the larger and finer specimens are almost completely submerged. Here where the water flows over these plants the thalli attain a diameter of eight to ten inches, and produce numerous, large cupules. At the outflow from the long pool (B of the map) near the bed of the fresh-water sponges, we found a species of *Utricularia*, but as we were unable to find any flowers or fruits we could not identify it with any degree of certainty.

No attempt has been made to secure any precise data concerning the composition of the aquatic flora of this restricted area, but perhaps the preceding paragraphs will suffice to give some little conception of how rich and varied this plant life really is. In order that the algologist, the bryologist or any other botanist may get a better idea of the composition of this aquatic flora, a brief statement is given here concerning the entire plant population.

Twenty genera of algae are growing here including blue-green, green and red algae, and a number of these genera are represented by more than one species. For example, Dr. R. C. Spangler, professor of botany in West Virginia University, to whom we are indebted for the identification of the algae, reported two species of Spirogyra, two species of Anabaena and five species of Oscillatoria. Miss Nelle Ammons, instructor of botany in West Virginia University, who identified the bryophytes, reported fourteen genera of liverworts and twenty-four genera of mosses involving a total of forty-nine bryophyte species. On the rocky slopes just out of the water and along the banks elsewhere there were found eleven species of pteridophytes, and more than a hundred species of typical fringing herbs, shrubs and trees. Doubtless an intensive study of this entire situation will reveal a number of species not observed by us in this first, hasty survey.

This wonderful region is now (1930) very easily visited. The best approach is over the well-graded road eastward from Moorefield. This highway crosses the mountain called Sandy Ridge just before reaching the village of Wardensville. A stone-throw above the river bridge, at the western foot of the slope and easy of approach on foot, is the place where Lost River sinks underground. Passing on over the mountain, just at its foot on the eastern side, perhaps a mile before reaching Wardensville, there is an obscure path running northwestward down the slope to the river. This path quickly leads to the portion of the Cacapon shown in our map. Just above the first trestle where the log railway crosses the river and within half a mile of the highway is one of the most interesting portions of the Cacapon. This railway parallels the river all the way through the gorge, making all points in it easy of access.

SPEAKERS AT THE DINNER GIVEN TO SIR JAMES HOPWOOD JEANS

SIR JAMES HOPWOOD JEANS; PROFESSOR MICHAEL I. PUPIN, PROFESSOR OF ELECTRO-MECHANICS AT COLUMBIA UNIVERSITY, AND DR. W. F. G. SWANN, DIRECTOR OF THE BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE. THE SCIENTIFIC MONTHLY WAS ONE OF THE SIX ORGANIZATIONS SPONSORING THE DINNER TO SIR JAMES, AND IT HAS THE PRIVILEGE OF PRINTING THE DINNER ADDRESSES IN THIS NUMBER.

THE PROGRESS OF SCIENCE

THE NEW PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES

Dr. William Wallace Campbell, who was elected president of the National Academy of Sciences by the unanimous vote of the members present at the annual meeting of the Academy on April 29 is the first astronomer to hold that high office. Three of his eleven predecessors—Alexander Dallas Bache, Joseph Henry and Albert Abraham Michelson—were distinguished physicists; three—William Barton Rogers, Othniel Charles Marsh and Charles Doolittle Walcott—geologists and paleontologists, and two—Wolcott Gibbs and Ira Remsen—chemists. Of the other three, Dr. William Henry Welch is known as a pathologist and physician, Dr. Thomas Hunt Morgan as a biologist, while Alexander Agassiz was both a geologist and an engineer.

The office is an honorable and an important one, not only because the membership of the academy is drawn from men of the highest standing in the various fields of scientific research, but also because the academy is the official advisory body to the Government of the United States on all scientific questions. When such questions are referred to the academy by the government, it is the duty of the president of the academy to appoint committees to investigate them, composed of members specially conversant with the subjects, to call in experts from the outside when he deems it necessary, and to act, ex officio, as member of all such committees. In addition to being a man of distinction in his own field of scientific research, therefore, he should also be a man of sound judgment and of broad experience in administrative and executive work.

In all respects, Dr. Campbell is fully qualified to meet the requirements of his new office. Coming to the Lick Observatory as astronomer in 1891, only three years after the observatory was transferred to the regents of the University of California, he was already known for his work in orbit computation and as a teacher of mathematics and practical astronomy. Here, he recognized the opportunity that was presented for applying photography to the investigation of stellar spectra, and, in particular, to the accurate measurement of the wave-lengths in such spectra, and therefore of the radial velocities of the stars or nebulae whose light they analyze. How well he improved that opportunity can not be related in detail here, but will be apparent to any one who will examine his book on "Stellar Motions"[1] or the Lick Observatory Bulletins and the volumes of the Lick Observatory Publications that are devoted to radial velocity results. True, Dr. Campbell did not do all this work alone; he had a number of able collaborators and many assistants; but he planned the work, set the standard, and in large part designed the instruments and developed the methods of observation and reduction, in addition to initiating and participating in the actual observing. The accuracy of the radial velocity results secured by him in 1896 with the original Mills spectrograph has not been surpassed anywhere even to this day. As to the importance of the results, it is not too much to say that the radial velocity work begun with the Mills spectrograph and 36-inch refractor at Mount Hamilton in 1896 and continued through the years there, and until 1928 at the station on Cerro San Cristóbal, Chile, constitutes the opening paragraph and some of the most significant later ones

[1] The Silliman Lectures, Yale University, for 1913.

DR. W. W. CAMPBELL

in what is one of the largest chapters in the history of modern astronomy.

The first total eclipse of the sun observed by Dr. Campbell was the one at Jeur, India, in 1898. Thoughtful study of the problem he had set himself to solve, thorough preparation, with careful attention to details, combined with observing skill and resourcefulness in emergencies—and, of course, clear skies—brought success on this expedition. This was repeated at the eclipses of 1900 (Georgia), 1905 (Spain), 1908 (Flint Island), 1918 (Goldendale, Washington) and 1922 (Australia). The only failure was in 1914, at the Russian eclipse, and that was due entirely to clouds. A volume[2] is in press at the present time which gives an analysis of the flash-spectrum plates secured by Dr. Campbell at several of these eclipses, and, in particular, at the one in 1905, by means of the moving-plate spectrograph, a novel instrument of his own design, which has the great advantage of giving a continuous record of the

[2] By Dr. D. H. Menzel, with an Introduction by Dr. Campbell.

spectrum of the chromosphere, as the moon gradually covers or uncovers it.

The particular problem at the 1922 (Australia) eclipse was to test, observationally, Einstein's prediction of the deflection of light in passing through the sun's gravitational field. Dr. Campbell designed the telescopes for this work with special care, to eliminate, so far as this was possible, errors from instrumental sources, and, with Dr. R. J. Trumpler's collaboration, carried out the program successfully. The observed deflection of starlight, in amount, and in the law of variation with increasing distance from the sun's limb, was in complete agreement with Einstein's prediction.

In 1900, the untimely and lamented death of Dr. James E. Keeler left the position of director of the Lick Observatory vacant. President Benjamin Ide Wheeler, of the University of California, in his search for the best man to succeed Dr. Keeler, wrote to the leading astronomers of America and Europe for nominations. Without exception, they all named Dr. Campbell! On January 1, 1901, he entered upon the duties of this office, an office he continued to hold until June 30, 1930, although for the seven years following July 1, 1923, he had to delegate to an associate director the active administration.

It was in that year, 1923, that he was called upon to assume the presidency of the university. He did not seek the office; indeed, when, immediately upon his return from the Australian eclipse, it was offered to him and urged upon him, he replied that he did not want it; that his highest ambition was to remain on Mount Hamilton as director and astronomer in the Lick Observatory. In the end, he found it his duty to accept, and how successful his administration was can best be shown by quoting the short address tendered to him by the Academic Senate of the university on October 7, 1929.

It is with profound regret that the Academic Senate has learned of your approaching retirement from the Presidency.

The extraordinary genius for organization previously demonstrated in the development of the Lick Observatory, in many eclipse expeditions, and in bringing about international co-operation among astronomers has made your present office a model of business efficiency. Every problem presented by a university department has been answered promptly and without ambiguity.

You have surrounded yourself with an unusual group of wise councillors and able executives in whose judgment the faculty has had confidence.

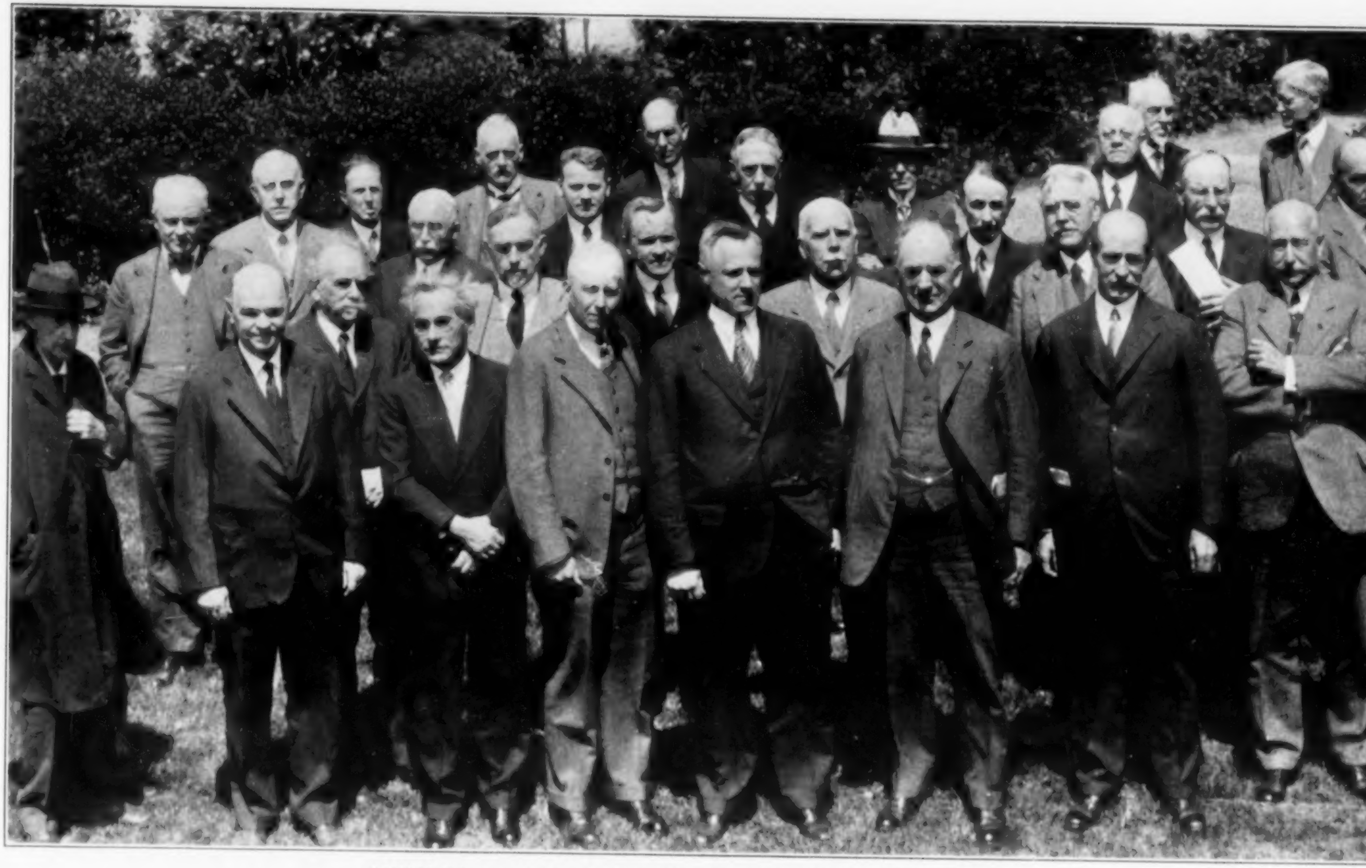
In the midst of complex external problems and great material development, your administration has not been diverted from the main purpose of a university, the advancement of teaching and of learning. The departments have been strengthened by the addition of men of distinction and by increased facilities for productive scholarship.

Your administration has been a period of tranquility and healthy growth such as few universities have enjoyed, and we, the Academic Senate, desire to express to you our heartfelt appreciation.

On June 30, 1930, Dr. Campbell retired from active service in the university, becoming President Emeritus and also Director and Astronomer Emeritus.

Space limitations forbid more than the mere mention of such facts as that Dr. Campbell was most active in organizing the International Astronomical Union, in 1919; that he served as president of the Union for the period 1922–1925; that he has been president of the American Association for the Advancement of Science, of the American Astronomical Society and of other scientific societies; and that his work has won recognition and honors in the form of medals, honorary degrees and other distinctions from universities and scientific societies at home and abroad. He brings to the office of President of the National Academy of Sciences the ripened judgment and wisdom gained from long years of distinguished service as a man of science and as an executive.

ROBERT G. AITKEN



MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES

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Millikan Bowie Kellogg Bowman Osborn Davis
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Hudson Levene Mendenhall Compton, K. T. Campbell, W. W. Keith Bogert

THE SPRING MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences was established by an Act of Congress, approved on March 3, 1863, by President Lincoln, to serve as adviser to the Government whenever called upon by any department of the government to "investigate, examine, experiment, and report upon any subject of science or art." This is a severe demand to make upon any organization and one that can be adequately met only by a membership of high standing. Viewed from this standpoint, election to the Academy means that, in the opinion of the Academy members, the new member is competent to serve the Academy effectively in case he should be called upon to do so. Each year at its annual meeting the Academy thus does honor to a number, not exceeding fifteen, of American scientists by electing them to membership.

The Academy holds two meetings each year, the annual meeting in April in Washington and the autumn meeting elsewhere. At each meeting there are open public sessions for the reading of scientific papers; also business sessions of the Academy attended by members only.

The constructive work of the Academy is done by committees of members having special qualifications for the work in hand. There are 17 standing committees of this nature; and in addition 18 committees for the administration of the different trust funds belonging to the Academy.

A special agency of the Academy is the National Research Council which was established in 1916 at the request of President Wilson. An Executive order, dated May 11, 1918, directed the Academy to perpetuate the Research Council for the performance of certain duties specified in the order. The National Research Council seeks "to promote research in the mathematical, physical and biological sciences and in the application of these sciences

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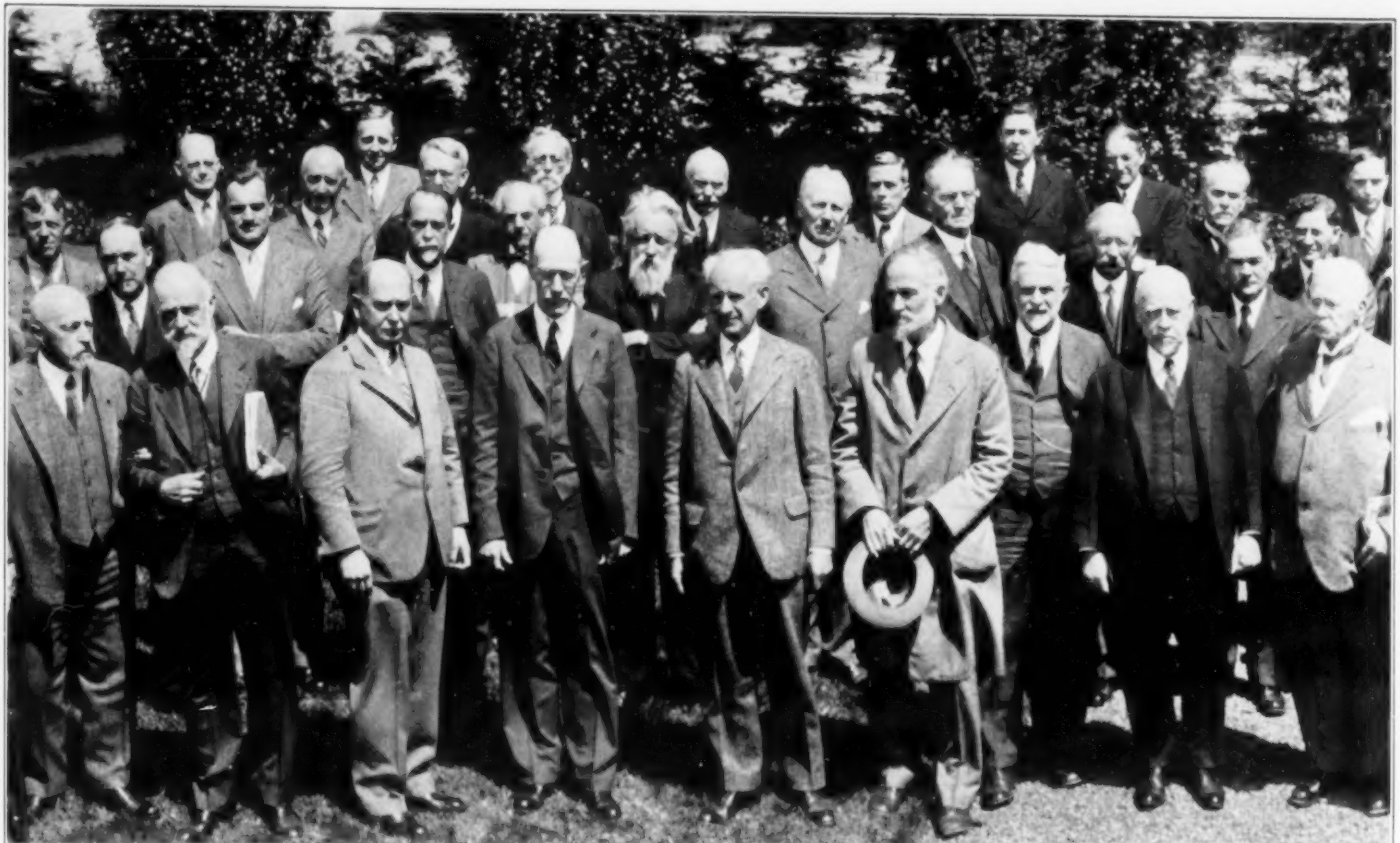
ASSOCIATE PROFESSOR OF PHYSICS,
HARVARD UNIVERSITY.



MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES

Brockett (*asst. sec.*) Wright, F. Stejneger McCollum
Stratton, G. M. Conklin Lillie Jones Hrdlička Shapley
Eisenhart Merriam, J. C. Compton, A. H. Morgan Cattell Washington Day Stockard Aitken Pillsbury Berkey Wissler Clinton
Howard Durand McClung Harrison Yerkes Leverett Welch Scott

A. KNOPF, PH.D.
PROFESSOR OF GEOLOGY, YALE UNIVERSITY.

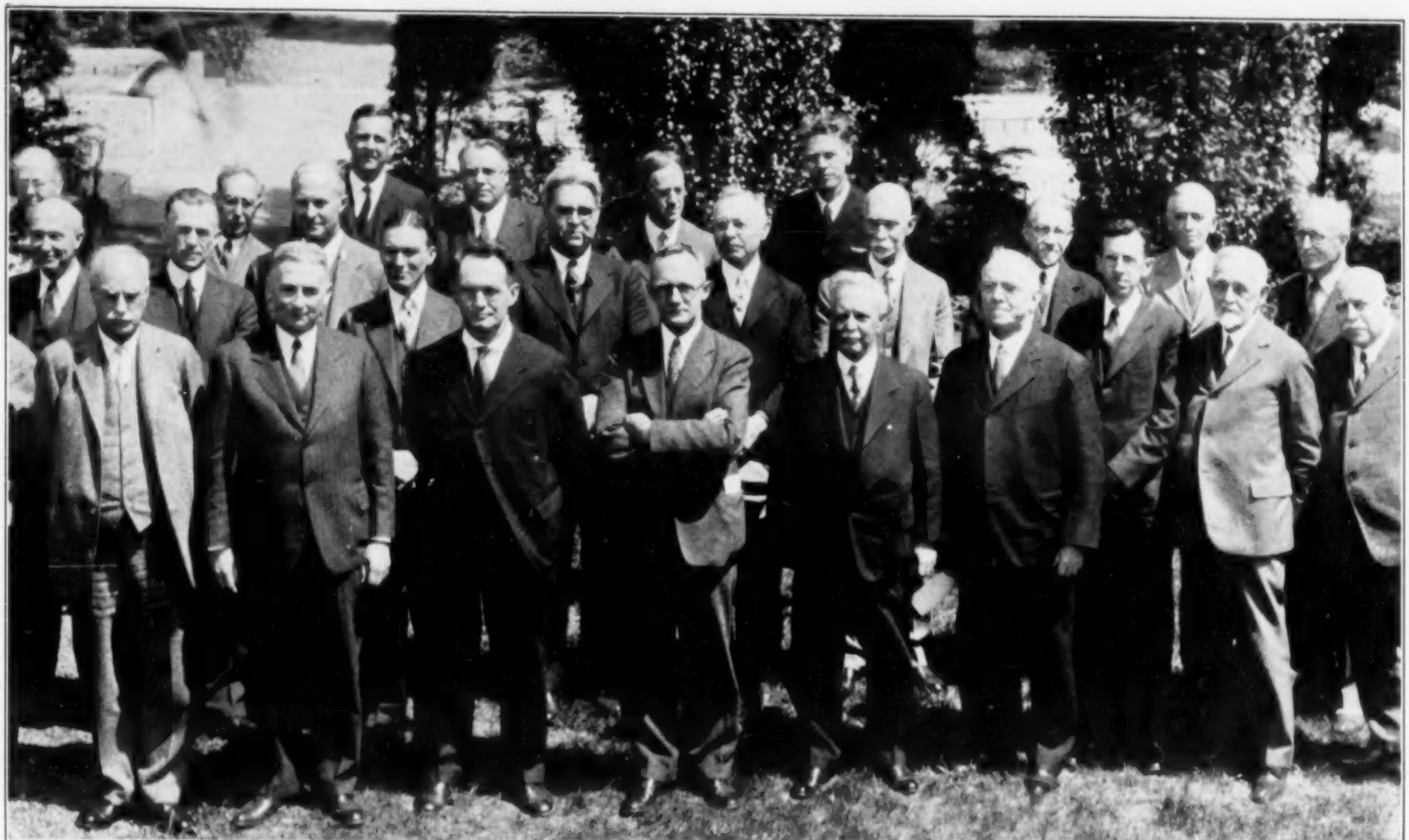
to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defense and of contributing to the public welfare." To this end "membership in the Council is

H. J. MULLER, PH.D.
PROFESSOR OF ZOOLOGY, UNIVERSITY OF TEXAS.

chosen with a view of rendering the council an effective federation of the principal research agencies in the United States concerned with these fields of science and technology." The Research Council has its own officers and membership and, within certain limits, determines its own policies and activities.

The National Academy of Sciences issues three series of publications: *The Proceedings*, a monthly journal containing short original statements of the results of scientific work; *Scientific Memoirs*, issued at irregular intervals and containing monographic contributions to scientific knowledge; *Biographical Memoirs*, containing memorials of the work and life of deceased members of the Academy. The National Research Council issues two series of publications: *Bulletins*, technical papers of considerable length; *Reprints and Circulars*, shorter papers of more general nature; also special reports by its several divisions and by the Geophysical Union, which is one of its committees.

G. L. STREETER, M.D.
DIRECTOR OF THE DEPARTMENT OF EMBRYOLOGY, CARNEGIE INSTITUTION OF WASHINGTON.



MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES

Mrs. Walcott (guest) Whipple Vebleh
Gomberg Allen, C. E. Cannon Bliss Vaughan Howell Noyes, A. Osterhout
Woodworth Bailey, I. W. Berry Ruedemann Davisson Burgess
Hall Harkins Bridgman Merrill Miller, D. C. Howe Mark

E. B. FRED, PH.D.
PROFESSOR OF BACTERIOLOGY,
UNIVERSITY OF WISCONSIN

The disbursements of the Academy, including the National Research Council funds, during the fiscal year, 1929–1930, totaled nearly $1,200,000; of this amount approximately one million dollars was for projects of the National Research Council; more than one half of this sum was for fellowships and grants-in-aid in the mathematical, physical and biological sciences.

This outline of the activities of the Academy and its allied agencies suffices to indicate that election to the Academy implies the acceptance of definite responsibility by each member to aid in carrying on the work of the Academy.

At the recent meeting of the Academy held in Washington on April 27 to 29 the following officers were elected for a period of four years:

President, *W. W. Campbell*, of the University of California and Lick Observatory.

Vice-president, *David White*, of the United States Geological Survey.

Home Secretary, *F. E. Wright*, of the Geophysical Laboratory of the Carnegie Institution of Washington.

Two new members of the council were elected for a period of three years:

W. B. Cannon, of Harvard Medical School.
Roger Adams, of the University of Illinois.

One foreign associate was elected:

P. Debye, of the University of Leipsic.

The new members elected were:

Henry Bryant Bigelow, Professor of Zoology, Harvard University and Director of the Woods Hole Oceanographic Institution.

Edwin Broun Fred, Professor of Bacteriology, University of Wisconsin.

Edwin Crawford Kemble, Professor of Physics, Harvard University.

Adolph Knopf, Professor of Geology, Yale University.

Robert Harry Lowie, Professor of Anthropology, University of California at Berkeley.

Joseph Haines Moore, Astronomer at Lick Observatory.

Robert Lee Moore, Professor of Mathematics, University of Texas.

Hermann Joseph Muller, Professor of Zoology, University of Texas.

George Linius Streeter, Director, Department of Embryology, Carnegie Institution of Washington at Baltimore.

Margaret Floy Washburn, Professor of Psychology at Vassar College.

Two medals were awarded at the annual dinner:

M. F. WASHBURN, PH.D.
HEAD OF THE DEPARTMENT OF PSYCHOLOGY,
VASSAR COLLEGE.

The *Daniel Giraud Elliot* medal for the year 1929 to *Henry Fairfield Osborn*, of the American Museum of Natural History, for his Monograph No. 55 of the United States Geological Survey on the Titanotheres of Ancieat Wyoming, Dakota and Nebraska. The presentation speech was made by *W. B. Scott*, of Princeton University.

The *Mary Clark Thompson* medal to *Edward Oscar Ulrich*, of the United States Geological Survey for outstanding contributions to geology and paleontology, especially of the Paleozoic of America. The presentation speech was made by Rudolf Ruedemann of the New York State Museum at Albany.

At the open scientific sessions 49 papers were read. The distribution of the papers among the sciences was: Astronomy, 3; Mathematics, 2; Engineering, 3; Physics, 12; Geology, Paleontology and Geophysics, 6; Chemistry, 3; Anthropology and Psychology, 2; Zoology and Biology, 10. The Monday evening Public Lecture was delivered by James H. Breasted, Director of the Oriental Institute of the University of Chicago, on "The Rise of Man and Modern Research." This extremely interesting lecture was attended by 660 people, the capacity of the Auditorium of the Academy building. At the scientific sessions the average attendance was 250. Attending the business sessions were 107 members of the Academy, out of a total membership of 253.

During the sessions Academy members and visitors viewed the exhibits set up in the rooms surrounding the Auditorium. This exhibition is maintained throughout the year and seeks to illustrate, in understandable form, certain fundamental principles of science. It is one of the outstanding features of the Academy building and is viewed by forty to fifty thousand visitors each year. The building itself is monumental in character and classical in design and is located on Constitution Avenue facing the Mall near the Lincoln Memorial. It is the home of the National Academy of Sciences and the National Research Council and is in keeping with the high purposes and functions of the Academy.

The autumn meeting of the Academy this year will be held on November 16 to 18 at Yale University.

F. E. WRIGHT,
Home Secretary

THE BUILDING OF THE NATIONAL ACADEMY OF SCIENCES